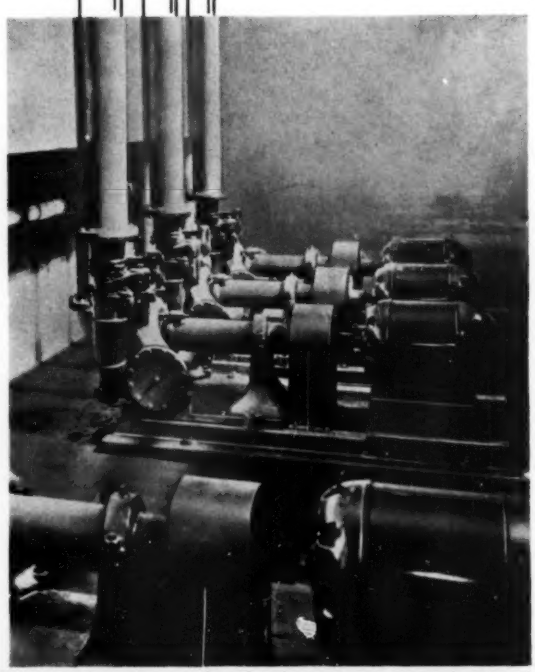
MINING ENGINEERING

APRIL 1951



MINING ENGINEERING

Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

VOL. 3 NO. 4 APRIL, 1951

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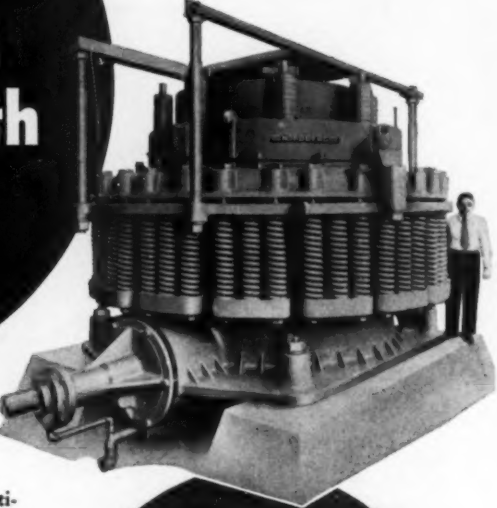
FEATURES

ARTICLES

TRANSACTIONS

COVER: Fossiliferous shale is expanded in this rotary, oil-fired kiln operated by the Empire Building Materials Co. 40 miles northwest of Portland, Ore. The expanded material is the newest competitor in the field of lightweight aggregates. This is but one aspect of the northwest's booming industrial minerals industry. **See P. 315 for a timely, interesting report on the Columbia River basin.**

MOST of the World's COPPER ORE is reduced with *Symons Cone Crushers*



To keep pace with modern industry's insatiable demand for more and more *copper* necessitates the use of the most efficient ore reduction machinery.

That's why most of the world's *copper* ore is reduced with Symons Cone Crushers. No other crushers can match their performance in producing a maximum of finely sized product at a minimum cost per ton.

Practically all the major producers in every country in the world where *copper* ore is processed in quantity benefit from the Symons Cone Crusher design that assures uniform controlled feed, maximum liner utilization, protection from tramp iron, and trouble-free operation. Built in both "Standard" and "Short Head" types, Symons Cone Crushers are unsurpassed wherever ores and industrial minerals are processed in quantity.

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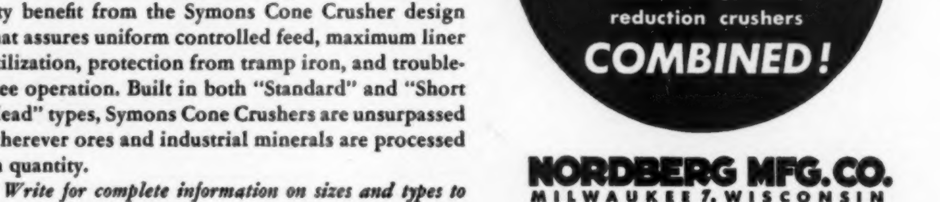

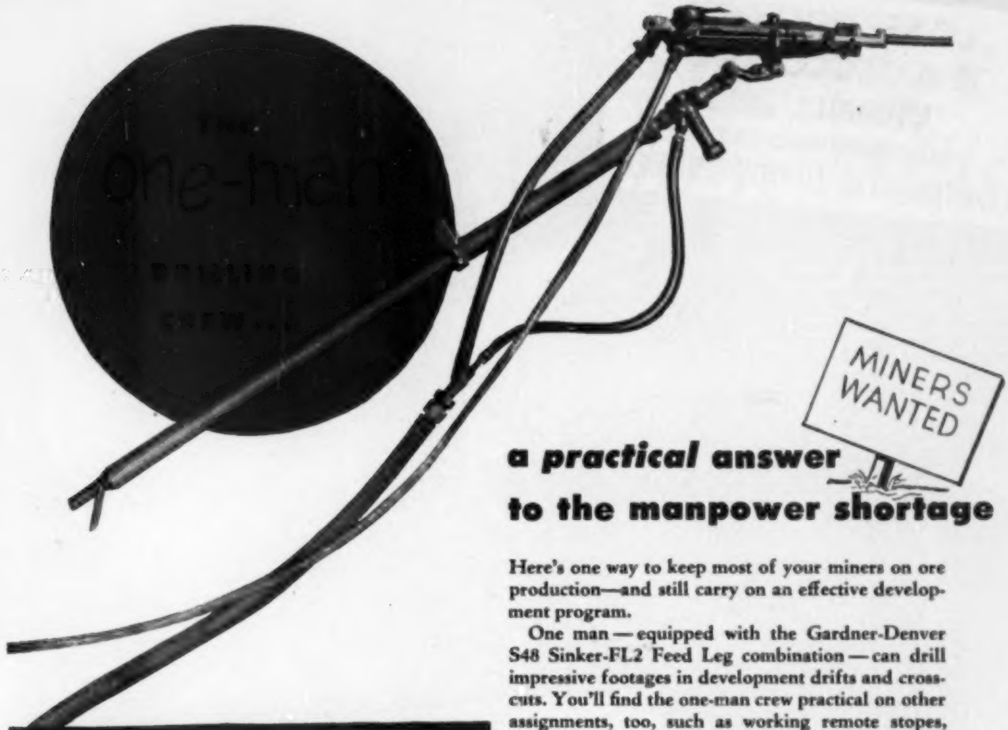

a *practical* answer to the manpower shortage

Here's one way to keep most of your miners on ore production—and still carry on an effective development program.

One man — equipped with the Gardner-Denver S48 Sinker-FL2 Feed Leg combination — can drill impressive footages in development drifts and crosscuts. You'll find the one-man crew practical on other assignments, too, such as working remote stopes, secondary breaking at draw points, eye-bolt drilling, etc.

This lightweight Gardner-Denver combination is specially designed for fast drilling with tungsten-carbide tipped rods and detachable bits. It consists of the new 45-pound S48 Sinker—the equal of most 55-pound drills in speed and power—mounted on the lightweight, long-travel FL2 Air Feed Leg.

Write us today for complete information.

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Heavy-duty shaft-sinking models also available.

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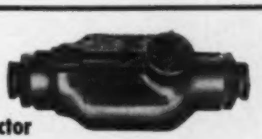

from the drill doctor

Drills lubricated by the L012 Automatic Line Oiler *can't* run dry—never show symptoms of inadequate lubrication.

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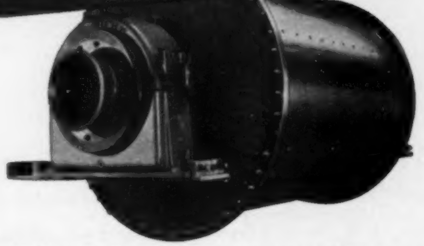
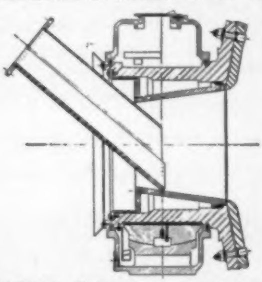
TRUNNION BEARING



EXTRA LARGE — Diameter of king-size Allis-Chalmers trunnion bearing is almost twice the bearing length, large enough to permit spout feeding. Large bearing proportions will provide long service despite heavy-going demands on mill. Internal oil system can be checked visually by means of hinged flap on bearing housing.

LOW BEARING PRESSURE — A spherical seat keeps mill in perfect alignment with bearings. Load is distributed evenly across full face of bearing, reducing wear. Cooling coils embedded in babbitted bearing cool the oil at point where most heat is generated. Piston ring seals hold oil in and dirt out . . . oil supply is always clean.



LONG BEARING LIFE — Internal oiling buckets carry lubricant to oiling pan. Oil is supplied the instant mill is started. All large bearings are fitted with lubricant pump for floating the mill during starting. This overcomes high starting torques and eliminates "dry" starting after shut-downs, which causes about 75 percent of bearing wear.

During normal operation, a film of lubricant separates trunnion from bearing. No metal to metal contact.

After a short shut-down period the thickness of this protecting film of lubricant is reduced.

After long shut-down, lubricant film is broken entirely. The result is damaging metal to metal contact between trunnion and bearing.

Lubricant pump floats the mill before starting . . . re-establishes protecting film of oil. Power needed for starting is greatly reduced, too.

Additional facts about trunnion bearings and other modern features of Allis-Chalmers grinding mills may be obtained without obligation from the A-C representative in your area or by writing to: Allis-Chalmers, Milwaukee 1, Wisconsin.

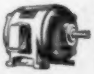
A-3348

Texrope is an Allis-Chalmers trademark.

Trunnion bearings are built by Allis-Chalmers in 10 sizes from 14 x 8 to 54 x 22-in. The six smallest sizes are available as grease lubricated bearings; seven largest sizes as oil lubricated bearings.

ALLIS-CHALMERS

Sales Offices in Principal Cities in the U. S. A. Distributors Throughout the World.



Motors

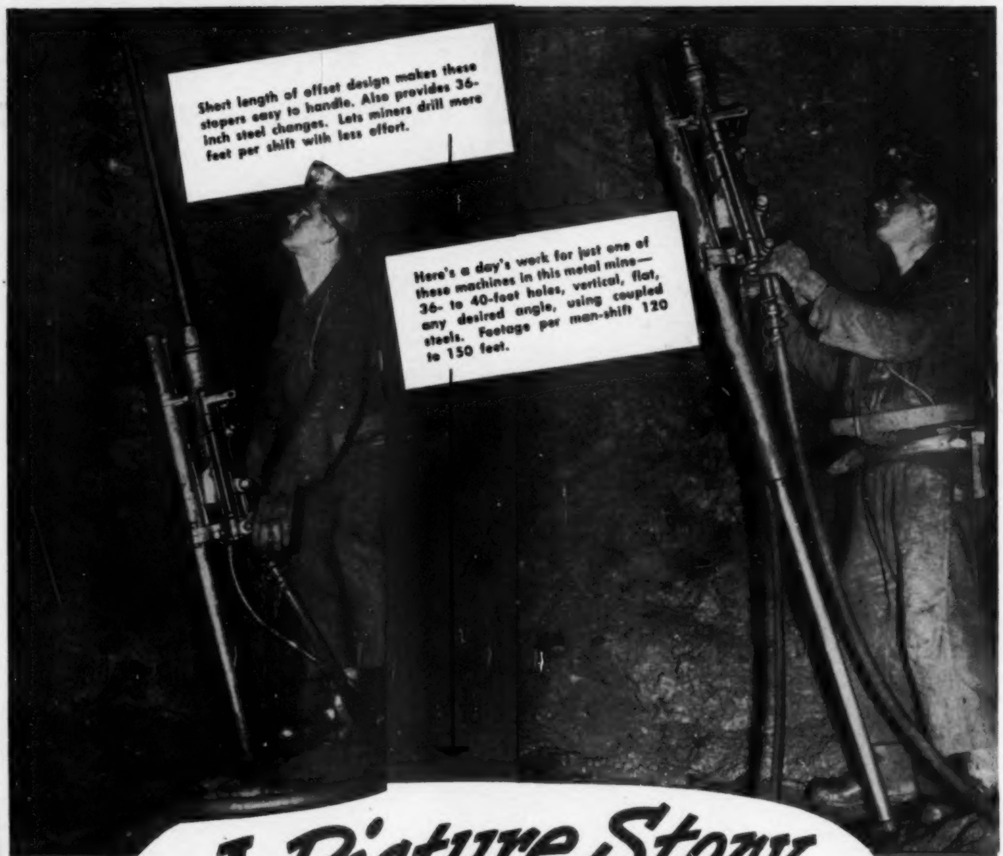
Controls

Texrope Drives

Vibrating Screens

Crushers

Kilns, Coolers, Dryers



A Picture Story of Lower Stoping Costs

. . . shows how Le Roi-CLEVELAND offset stopers drill extra footage, save you money

Take a good look at these pictures. Note the length of the drill steel. Fitted with carbide-tipped bits, it gives you 36" of drilling—3 feet with every change.

That's one of the reasons why Le Roi-CLEVELAND offset stopers are paying off in lower drilling costs.

But it's not the whole story. The machines shown here are equipped with downstroke rotation. This gives plenty of power and lets the miners drill holes from 36 to 40 feet in depth — using coupled steel. Total footage drilled per man-shift runs from 120 to 150 feet.

Performance like this does a lot to keep costs down. It also accounts for the growing popularity of Le Roi-CLEVELAND offset stopers wherever stoping is a problem.

Other features of these machines are: Removable water tube — no need to dismantle the machine. Graduated feeding pressure. Constant blowing at chuck keeps machine clean. Write us today for complete details.

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RD-23

CLEVELAND ROCK DRILL DIVISION

12500 Berea Road, Cleveland 11, Ohio

Plants: Milwaukee, Cleveland and Greenwich, Ohio

Not

pious hopes

but ....

Figures

So many opinions, so few real facts on abrasive wear! Here are figures of long-time tests from actual ore-grinding practice.

Case No. 5

Tests at a large mine grinding low-grade copper ore.

Service: Marcy 10′ × 10½′ grate discharge type ball mills grinding minus ¾″ feed to 84% minus 100 mesh. Mill speed 18 rpm. Balls charged were 2½″ and 2″ dia.

Comparison: Between one set of austenitic manganese steel grates in concurrent service with chromium-molybdenum cast steel grates, (normalised and tempered to 275 brinell).

Grate Type: Marcy design cast steel with slot openings ¾″ to ⅞″ wide.

Results:	Life—Days	Tons—per set
Manganese Steel	323 *	590,703 *
Cr-Mo Steel (ave.)	402	739,242

* Manganese steel grates removed before completely worn out, due to excessive peening of the bars, which closed-up the slot openings.

Case No. 6

Tests at a large mining operation grinding copper ore.

Service: Marcy 9½′ × 12′ rod mill grinding minus 2″ feed to minus 10 mesh. Speed 16.6 rpm. Replacement rods were 3″ dia.

Comparison: Between one set of martensitic (Ni-Hard) liners and one set of high carbon chromium-molybdenum cast steel liners, (salt quenched and tempered to 350 brinell).

Liner type: Shell (barrel) liners with specially designed square corner lifter.

Results:	Tonnage ground
Martensitic white iron	348,000 *
Cr-Mo Steel	404,426

* Several liner plates in this set replaced due breakage before remainder were worn out.

Write for 32 pp reprint of an informative paper published by the Amer. Inst. of Mining and Metallurgical Engrs., giving results of wear tests on grinding ball materials—FREE !

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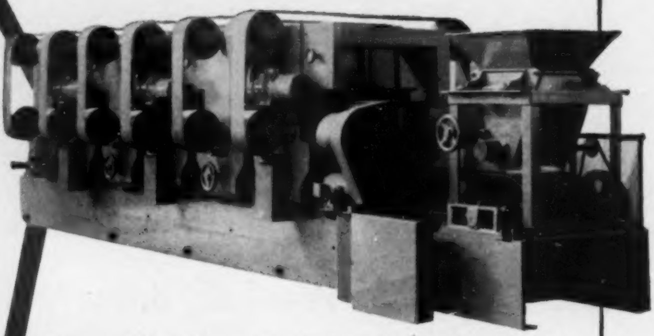
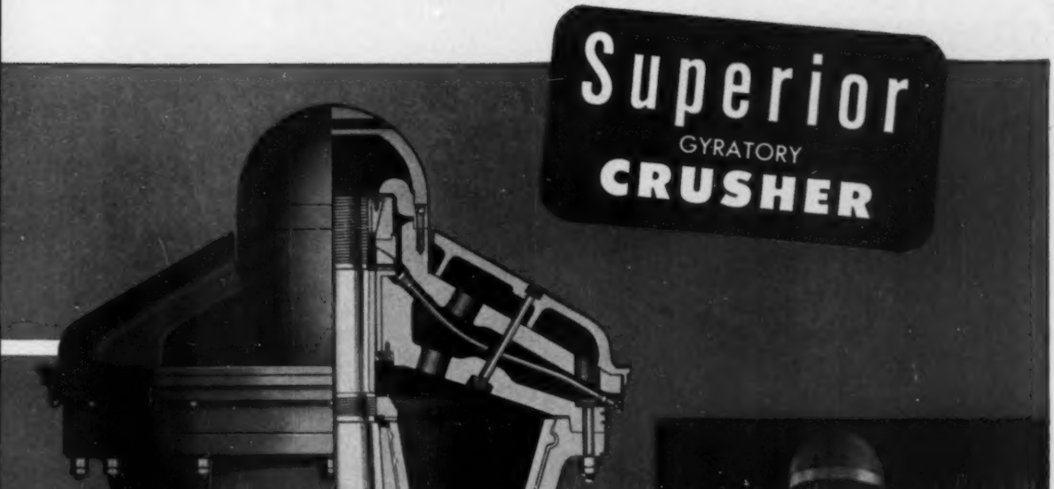



50 LB.
HERCULES
GELAMITE
2
HERCOMITE
4

Primary Crusher

IMPORTANT ADVANTAGES?



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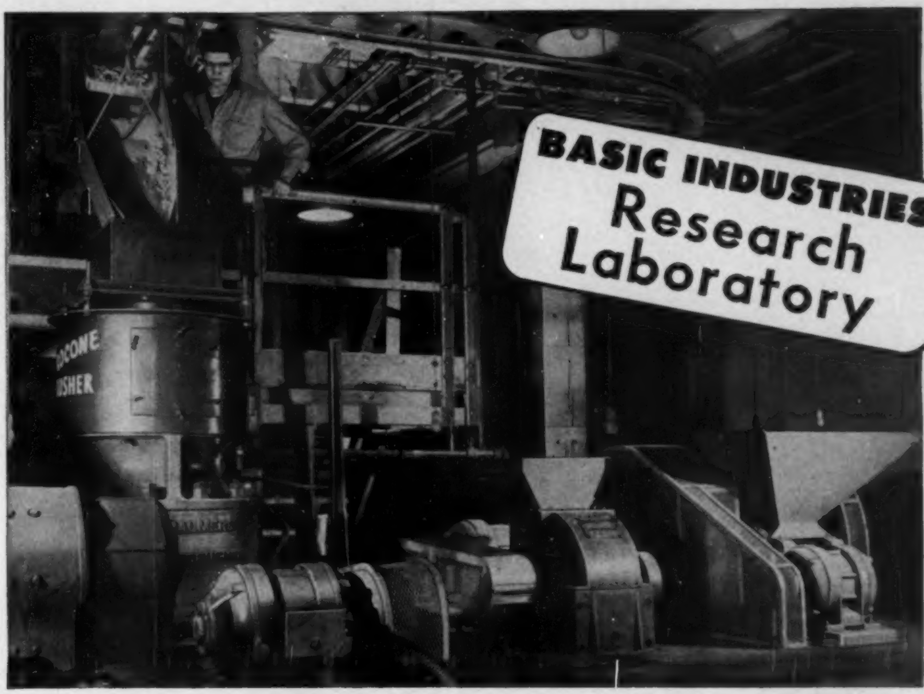


Can You Use These Facilities?

THE ALLIS-CHALMERS Basic Industries Research Laboratory is open for business — to help you work out profitable solutions to processing problems. It contains modern equipment for both batch and pilot mill tests in grinding, crushing, sizing, concentrating, jigging, pyro-processing, as well as chemical and physical analysis.

The Laboratory's purpose is to develop new or more efficient processing methods . . . to determine the economics of a process prior to full scale production . . . to provide engineering information to guide in the designing of efficient plants.

Use of the facilities of the laboratory are available to anyone in industry. Charges are based on costs. Estimates for test work can be obtained from the A-C district office in your area or by writing direct to Allis-Chalmers Research Laboratory, Milwaukee 1, Wisconsin.

HERE'S HOW LABORATORY SERVICE WORKS:

A manufacturer of rock products wanted to crush and grind a granite rock to produce material for roofing granules.

A considerable amount of equipment would be required, and before making this expenditure the company wanted to be sure that not too much material would be lost as fines in the process. It was estimated that a 50 percent recovery would be commercially practical.

The problem was brought to the Allis-Chalmers Basic Industries Laboratory for crushing and grinding tests. A ton of the granite rock was run through the Laboratory's pilot mill and a flow sheet was worked out which resulted in 70 percent recovery of finished product.

As a result of the tests, this manufacturer was able to proceed with confidence in setting up new equipment . . . with only a nominal expenditure for preliminary pilot plant testing.

Free

Write Allis-Chalmers, Milwaukee 1, Wis., for Bulletin 07B6419B.

Name

Company

Position

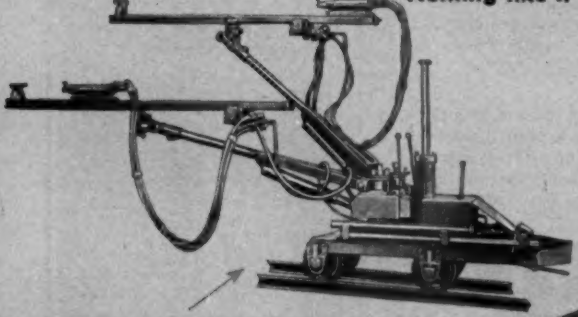
Address

City State

A-3338

ALLIS-CHALMERS

Basic Industries Research Laboratory — Dedicated to a Better Utilization of our Raw Materials



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give you Faster, Better, Lower-Cost Drilling!

For TOP Performance—
JOY Silver Streak Drifters and Telescopic Stopers

Joy SILVER STREAK Drifters and Stopers are built for long service with low maintenance, and fast drilling at less cost per foot of hole. Exclusive features include cadmium-plating inside and out, which prevents rusting, eliminates scoring of piston and cylinder, and aids lubrication ... and the patented Joy Dual Valve, which "makes air do more work."

The drifter line also features the Joy locking chuck, and longer feeds. Joy Stopers feature "thumb-flip" rotation control, and include both a safety stoper and a new telescopic feed stoper (illustrated) which affords longer feeds and requires fewer steel changes, giving more time for drilling.

Proved Advantages—Now for the First Time
ALL INCORPORATED IN ONE DRILL JIB!

AIR-DRAULIC CONTROLS—All jib movements are automatic. An air-motor-powered hydraulic pump does all the work. Drills can be raised, lowered, or swung to any position in seconds by double-acting cylinders—a new feature *pioneered* by JOY.

POSITIVE HYDRAULIC LOCK—Two hydraulic cylinders lock the boom firmly in place both horizontally and vertically while drilling—another *exclusive* JOY feature.

STURDY JIB ARM—Made of high-strength steel for adequate support of the drill and "long feeds." Standard boom may be either seven or ten feet. Extendable booms are available which will extend to 9½ and 12½ feet.

POWERFUL "PISTONMOTOR" FEED—Highly efficient air motor with only two moving parts. Single control gives instant reaction to any desired feed pressure.

GREAT ADAPTABILITY—Joy Hydro Drill Jibs are available either on mobile mountings (rubber-tire or track models) or supplied as individual units to be mounted on large jumbos, truck beds, etc. as your operations require.

Consult a Joy Engineer

W&D M 3392

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IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LIMITED, GALT, ONTARIO

Personnel Service

THE following employment items are made available to AIME on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York Office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer, 38, married, three children school age, speaks, writes Spanish, English. Now employed engineering dept. large copper company South America, desires position mill superintendent, construction, field or office engineer; 14 years' experience these lines. References furnished; available May 1951. M-612.

Mining Geologist, AB, 27, veteran, single. Twenty months' experience assistant mine engineer, shrinkage stope iron mine. Speak, read, and write fair Spanish and German. Mapping, reports, measurements, etc. Desires advancement, travel, and wider experience. Go anywhere. Available 30 days notice. M-615.

Mining Engineer, 32, married. Ten years' technical experience underground development and mechanization in metallic and nonmetallic mines. Surveying, mapping, mechanical-structural design and surface plant construction. Seeking progressive position in mine plant engineering. Prefer western New York State or Ohio area. M-617.

POSITIONS OPEN

Mining Engineers, graduates. (a) Mining engineer to act as office engineer. Must have had three or four years' experience in field surveying and office engineering. Will be required to assume charge of mining department in the engineering office. Will be responsible for the proper functioning of and must be able to coordinate field surveys and maintain records of same. In connection with legal department, he will handle property and squatter problems. Should be able to assist mining engineer in administrative matters

(Continued on P. 305)


Only Carlon...
THE FIRST REAL PIPE THAT IS PLASTIC
ONLY CARLON plastic pipe is guaranteed against rot, rust, and electrolytic corrosion. This durable, lightweight pipe has a trouble-free service life many times longer than ordinary pipe because it is unaffected by sulphurous waters, alkalis, metallic salts, and other corrosive wastes.
Both flexible and rigid types of CARLON are available to meet the diversified requirements of surface and subsurface mining operations. Flexible pipe is furnished in long lengths and will conform to irregular surface contours or ditch lines. In addition, it requires fewer fittings per installation than any other pipe. Rigid CARLON is shipped in 20-foot lengths which can be made-up rapidly with either cemented-sleeve or threaded connections, and it can be threaded with standard pipe tools to meet individual requirements. Extensive research and field testing have proven conclusively that CARLON plastic pipe is superior to other mine pipes, and that it eliminates costly maintenance and replacement programs.
Remember . . . when you pipe for the future, specify ONLY CARLON.
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Bear Brand Xanthates

Universal . . Adaptability

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- **Z-3—Potassium Ethyl Xanthate**
- **Z-4—Sodium Ethyl Xanthate**
- **Z-5—Potassium Amyl Xanthate***
- **Z-6—Potassium Pentasol Amyl Xanthate***
- **Z-8—Potassium Secondary Butyl Xanthate**
- **Z-9—Potassium Isopropyl Xanthate**
- **Z-11—Sodium Isopropyl Xanthate**

*From Sharples Amyl Alcohols

Extremes in climatic conditions do not adversely affect the quality and usefulness of Bear Brand Xanthates.

From the frigid zone to the tropics, years of extremely diversified operating experience have conclusively demonstrated that optimum economic and metallurgical results are achieved by the use of Bear Brand Xanthates.

Time and experience have demonstrated the universal adaptability of these outstanding reagents to the successful flotation treatment of practically all sulphide ores, as well as some oxidized ores and certain ores containing native metal.

GREAT WESTERN DIVISION · BEAR BRAND PRODUCTS · THE DOW CHEMICAL COMPANY

DOW

"Over Twenty-five Years Experience in Producing Xanthates for Metallurgical Use"

THE DOW CHEMICAL COMPANY

San Francisco 4, California, U. S. A.

— Personnel Service —

(*Continued from page 302*)

and in planning and estimating job orders for mining department. Knowledge of Spanish desirable. (b) Assistant field engineer in the mining department. Must be able to assist mine supervisor in direct supervision on special engineering investigations and construction projects as assigned. Must be able to interpret drawings and specifications and advise his foreman in planning and layout. May be required to assist in routine and other surveys. Open-pit experience desirable. Knowledge of Spanish desirable. Salaries, $4800-$6000 a year plus room and board expenses. Must go on single status for two-year period. Transportation to and from paid by company. Location, Venezuela, S. A. Y5097.

Engineers. (a) Assistant to mine superintendent, about 40, mining graduate, with experience, including shaft sinking and square set stoping. Should be capable of supervising the detail underground operations. State salary required. (b) Shift Bosses, mining graduates, with at least two years' underground mining experience including square set stoping and shaft sinking; older men without the technical training, but under 50 years of age suitable. Will work shift work. Salary, $366 a month—housing furnished for $7.50 a month with electricity, water services supplied, if married. Location, North Carolina. Y5087.

Mining Engineers, two, young, preferably with one to four years' underground experience. Should be interested in mine surveying, mine geology, operational planning, time studies and mine structural design. Salary, $3900-$4800 a year to start, depending on qualifications. Traveling expenses paid. Location, New Jersey. Y5070.

Plant Engineer, 30-45, mechanical or mining graduate, who has had some experience in open-pit mining and flotation. Should have knowledge of driers, rotary filters and de-watering equipment. Salary, $6000-$8000 a year plus living quarters. Location, Florida. Y5069.

Chief Mining Engineer, under 50, for work in connection with preparation plants; should be able to design or supervise the designing of coal mining equipment and preparation plants. Salary open. Location, Alabama. Y5045.

Engineers. (a) Mill superintendent with minimum of five to ten years' experience in the operation of a mill for metal mining company. (b) Four assistant mining engineers for metal mining operations in the Philippine Islands. Salaries open. Y5022.

Exploration by AS&R of the Nuestra Senora lead-zinc-silver property, located in Cosala District, Sinaloa, Mexico, has proved sufficient ore to warrant placing the mine on an operating basis. Installation of mine plant, concentrator, and townsite, is expected to commence late in 1951. Opening of a lead-zinc property in Nigeria is also being contemplated by AS&R.

Private enterprise is being urged by Secretary of Interior Chapman to start a synthetic fuels industry, it is reported. Based on tests at the Louisiana, Mo., plant which produces quality gasoline at costs up to 12½¢ per gal, he predicts that a commercial plant would pay for itself in 10 years.

The United States steel industry passed the 100 million ton annual ingot capacity mark for the first time in 1950. This is 12 pct more than the peak wartime production and is approximately equal to the combined steel capacity of the rest of the world.

Export of cobalt ores and concentrates may be banned by the Canadian government shortly to assure the success of a 3-year stockpiling program in that country.

Freeport Sulphur Co. is reported to have an option to purchase a pyrrhotite ore property from Virginia Iron, Coal and Coke Co. situated in Carroll County, Va. The sale would involve a transaction of $2½ million.

When International Nickel's transition from open-pit to underground mining is completed in 1953, production will amount to 13 million short tons of ore from underground. Approximately $20 million will be spent on this program in 1951.

Test running of America's first gas-turbine electric locomotive by Union Pacific proved the efficiency of this type of prime mover in railroad work. Ten additional locomotives of this type are now on order from General Electric.

Noranda Mines, Ltd. is planning the development of a large low grade copper orebody on the Gaspe Peninsula section of Quebec. Reserves are estimated at 57 million tons of 1 pct copper. Production capacity of 5000 tons per day is contemplated.

"With or without the Seaway, 10 million tons a year of Labrador-Quebec iron ore will move to market."; according to George M. Humphrey in the annual report of the M. A. Hanna Co. Without the Seaway expansion will be slow, he went on to say.

Dr. J. R. Van Pelt has been named president of the Montana School of Mines it was announced recently by Governor of Montana, John W. Bonner. Dr. Van Pelt is succeeding the late Dr. Francis A. Thomson and Arthur E. Adami, who was acting president. Dr. Van Pelt is a mining engineer and research executive who is leaving Battelle Memorial Institute to accept the new post.

Prevention of screen blinding in screening operations on fine materials is reportedly achieved by electric resistance heating of the screen wires.


VENT
OVERFLOW SECTION
OVERFLOW
FEED
VORTEX FINDER
FEED SECTION
CONICAL SECTION
APEX VALVE
TAILPIPE
UNDERFLOW
New solution to an old problem!
here's an economical way to produce mine backfill from mill tailings...

Critical Shortage of Engineers

MAN POWER commitments for defense, superimposed on normal domestic requirements, exceed the available supply of labor. The armed services, industry, and the professions are sizing themselves up man power-wise and are announcing that serious shortages are imminent or already in existence. The engineering profession is facing serious shortages. The main reason for this is the recall of engineering and scientific personnel to the armed services.

A recent survey of the petroleum industry disclosed that one third of all engineering or technical personnel are now subject to call to the military. At first glance this seems astounding, but assuming a full-scale war it is obvious that about one third of all man power, engineering or otherwise, would be subject to draft or recall as reservists. This information is a warning of the number of engineers that will be needed in the event of full mobilization.

Since the end of World War II there have been bumper crops of engineering students, reaching the all time high of 57,507 in 1947. By 1950 the graduating class had fallen to 26,500, less than half of the 1947 total. Record enrollments caused many student career counselors and even college officials to predict a surplus of engineering graduates. S. C. Hollister, dean of the College of Engineering at Cornell University recognized the fallacy of this reasoning. He argued that GI enrollments were responsible for the surge but that it would be followed by lean years because the high school enrollments were falling off. The generation born during the depression of the thirties was a small one and will come of college age now and for the next four or five years. By 1954, fewer than 10,000 engineers will be graduated.

The estimated annual consumption of engineering graduates under present conditions is 30,000. Beginning in 1952, the already tight situation for engineering personnel will be getting progressively worse as the replacement supply falls below minimum requirements. Attempts are being made to alleviate this serious situation. Criteria by which it may be determined whether engineer-reservists are more critical in their civilian occupations or recalled to duty are being considered. Machinery for keeping them on the jobs that fulfill critical requirements is being studied.

The Engineer's Joint Council is launching a $100,000 campaign to inform the public of the importance of the engineering function and to insure more effective use of engineers in industry, construction, and the armed forces. The three main objectives of the campaign are to increase engineering enrollments, to assure better utilization of present engineering man power, and to act as consultant to Government bodies in order to assist in conservation of engineering man power.

The AIME through its Local Sections can help to increase the number of engineering graduates. The Student Affairs Officer of each Local Section should make a point of visiting all AIME Student Chapters during the year, and on this visit he should stress the importance of remaining in school as long as possible rather than enlisting in the service prematurely. Committees of Local Sections should be formed either under the auspices of the Engineers Council for Professional Development Committee on Student Selection and Guidance or independently for the purpose of visiting high schools at the request of guidance counselors. These visits present an opportunity for practicing engineers to tell high school graduates of the need for engineers.

It is imperative that a far-flung effort be made to use engineering man power efficiently and to stimulate engineering enrollments in our colleges lest industry and the mobilization program be seriously impaired by an acute shortage of trained men.

Student Relations, Plus

ANNUAL Meetings of AIME are an excellent opportunity for the mining engineering profession to shake hands with, and look over, a portion of the students who are "would-be" mining engineers. Never has this opportunity been taken so completely as at the St. Louis Annual Meeting. For one thing, registration was free for AIME Student Associates. Reduced rates for students applied to most social affairs and a panel of experts from all branches of the mineral industry was on hand one afternoon of the meeting to discuss careers in the mineral industry.

The Minerals Beneficiation Division went a few steps further by taking a personal interest in each prospective mill man. Each student interested in the activities of this Division was taken under the wing of a practicing "beneficiator." Like father and son these pairs appeared at technical sessions and social affairs alike. Consultation on technical problems or employment possibilities was standard procedure.

The atmosphere at St. Louis was conducive to equal participation by students and engineers. We wholeheartedly congratulate the St. Louis Section of AIME and the Minerals Beneficiation Division for foresight and understanding in conducting the meeting in this way. Each Division should consider establishing a similar program for students at its next meeting. This type of business-social contact with the future engineers of the industry is the best possible way to encourage them and steer them into the profession.

Trends

A REPORT OF CURRENT ACTIVITY IN THE INDUSTRY

THE game of "go find the strategic minerals" was made more enjoyable recently when the Government enlarged the kitty by $10 million, thus encouraging prospectors and mine operators to work a bit harder, and guaranteeing that they will have some assistance in developing worthwhile deposits. The money will be dispensed by the Defense Minerals Administration, with Government funds to be matched on about a 50-50 basis by private capital. In some special cases Uncle Sam may put up more than half of the necessary capital, but in all cases the money is repayable from net production income if the venture is successful. Federal funds may be used only for direct costs and operating overhead, and not for administrative expenses not directly related to the project. Government engineers and geologists will perform periodic checks, and operators must maintain adequate records of each project.

- **The fair name of depletion allowances was** bandied about in the nation's capital during February and March. Turns at bat were taken by President Truman, the AFL, ESA administrator Eric Johnson, and others. On March 5 a platoon of industry representatives invaded the House Ways and Means Committee hearings in strong defense of percentage depletion allowances, and in search of changes in the income tax law. It will be recalled that the President, on Feb. 2, spoke of "gross under-taxation of the oil and mining industries . ." Three days later Secretary of the Treasury Snyder moved in on the House Ways and Means Committee and took a few more whacks at percentage depletion, registering particular objection to the fact that depletion continues to be deductible "even after 100 pct of the investment had been recovered tax-free." Arthur A. Elder of the AFL called for plugging of tax "loopholes" shortly after Secretary Snyder's appearance, and the Committee announced simultaneously that it would explore all possible additional sources of revenue before writing the tax bill with the new ten billion dollar fringe on top.

  Industry's representatives at the March 5 gathering of the clan included D. A. Callahan and H. B. Fernald of the American Mining Congress, M. D. Harbaugh of the Lake Superior Iron Ore Association, Freeport Sulphur's president L. M. Williams, and Fred O. Davis of the Potash Co. of America. Replying to Secretary Snyder's objections to depletion allowances, Mr. Callahan found that "no actual figures as related to metal mines have ever been given in support of such a statement . . . (the Secretary) refers to 'capital' as 'money invested'. In the case of mines it is an utterly erroneous assumption. The 'capital' of a miner is the metals and minerals contained within the boundaries of his property. His 'investment' . . . cannot be measured in dollars and cents."

  Mr. Fernald accented the necessity for providing adequate exploration incentives, and told the committee that adequate depletion allowances were necessary, in addition to recognition of expenses incurred in prospecting, which should be written off as operating expenses in the year incurred or against resulting ore. Clarification of the special provision for special amortization, and amendment of Sect. 122 (the net operating loss provision) so as not to deny percentage depletion in the year of loss were also suggested by Mr. Fernald. Messrs. Harbaugh, Davis, and Williams spoke in like vein for the iron, potash, and sulphur industries respectively.

- **Two cents, a rather useless sum to Homer Q.** Citizen, and an absurdly small one in this, the era of millions and billions, stood forth like the proverbial sore thumb in recent days. Pounding on the thumb were Louis S. Cates and C. D. Dallas, board chairmen, respectively, of Phelps Dodge Copper and Revere Copper and Brass. The two cents represent the current tariff on copper imported into the United States. Mr. Cates, in presenting his company's annual report, claimed that the high price of foreign copper, and not the tariff, is acting as a deterrent to buyers. To buttress his argument he cited the 48,007 tons of copper a month that were imported during the last five months of 1950. He went on to demand that any suspension of the tariff (President Truman and others have called for suspension) should provide for automatic restoration when excessive imports threaten the domestic industry. But Mr. Dallas, recently returned from pow-wows with the President of Chile, said the tariff ". . . is an economic absurdity and has been such for ten years." Abolish it, said he, instead of just suspending it. This was offered as part of a plan to relieve the shortage of copper by developing Chilean deposits. Among his other suggestions were: maintenance of purchasing power of dollars received by Chile for copper, government absorption of the price spread between United States and Chilean copper (as practiced during the last war), and arrangement of priorities for importation of copper-producing machinery into Chile. Mr. Dallas praised Charles E. Wilson's recent move in curtailing the rate of stockpiling copper.

- **Preliminary hearings of the House Public Works** Committee on the St. Lawrence Seaway came to an end at the beginning of March. Besides support from President Truman, the proposed Seaway has been spoken for by Defense Mobilization Director Charles E. Wilson ("an absolute necessity"), George M. Humphrey, president, M. A. Hanna Co. ("a vital necessity"), and N. W. Foy, general sales manager for Republic Steel (". . . a great sheltered channel impervious to all but air attack").

- **As Senate Finance Committee hearings on the** Trade Agreements Act continued, the coal industry came forward, in the person of Robert E. Lee Hall of the National Coal Association, to claim severe damage from the existing policy of un-

limited importations of foreign oil. In 1949, Mr. Hall said, 25,000 miners and an equal number of transport workers lost their jobs as a result of foreign oil imports that supplanted 150 million bbl of U. S. oil and resulted in a residual surplus of 100 million bbl. The coal industry suffered a $125,000,000 loss in gross income, and the railroads lost $75,000,000 in freight revenues, Mr. Hall claimed. One powerful argument for reducing oil imports, he noted, was the fact that foreign oil sources would be cut off in case of all-out war.

- **Ore miners in Alabama contributed directly to** a loss of over 100,000 tons of steel within recent weeks by striking against the Tennessee Coal, Iron and Railroad Co. in Birmingham. Coal miners joined the iron miners in the strike, but they both went back to work on Mar. 7, their 11-day walkout ended by the promise that agreement could be reached more quickly if they were back on the job.

- **Uncle Sam gave the quietus to a very jumpy tin** market on Mar. 7 by announcing cessation of all new tin purchases for the government stockpile. In Singapore and London, tin prices have been rising at an alarming rate during the last few months, and since the price freeze order here, American purchasers have been unable to buy foreign tin and sell it within the 183½c ceiling. Both foreign and domestic tin prices moved downward following the announcement.

- **The $.5 million ore pier built by the Baltimore &** Ohio Railroad in Baltimore will be completed early this month and foreign ore shipments will soon begin arriving. Designed to unload a vessel within 24 hr, the pier will handle iron ore from Liberia and Venezuela.

- **Kennametal, Inc., has begun a $500,000 expansion** program that will increase the availability of basic ingredients for the company's products. These involve the treatment of tantalite, columbite and titanium ores; recovery of nickel and cobalt from ores, oxides and intermediate products, and the refining of tungsten carbide directly from ores and oxides.

- **A new iron ore mine will be opened two miles** east of Crystal Falls, Mich., by the Inland Steel Co. Development will start immediately, with production expected in late 1952. A 200,000-ton annual production rate is anticipated.

- **A 200-ton mill to process uranium found in lime**stone may be constructed on the Navajo reservation in northeastern Arizona. Federal Agents, the Navajo Tribal Council, and mining representatives discussed the proposal recently. Blair Burwell, president of Minerals Engineering Co., Grand Junction, Colo., characterized the area as one of the world's greatest sources of atomic energy raw materials.

- **Industry is not responsible for all the smog in the** Los Angeles area, the Stanford Research Institute has found. The activities of the general public are responsible for 65 pct of the aldehydes in the air, 73 pct of the ammonia, 40 pct of the nitrogen oxides, 24 pct of the sulphur oxides, 31 pct of the acids, and 46 pct of the solids. Industry is believed responsible for the remainder in each case. Household burning of trash, and exhaust from about 2 million buses and automobiles are the chief source of organic chemicals in the air, which comprise two thirds of the smog.

- **A new bonus for domestic uranium ore and a** price increase for Colorado plateau ores have been provided by the Atomic Energy Commission. For the next three years the Commission will pay a graduated bonus of up to $35,000 for initial production and delivery of acceptable uranium ore from new and certain existing properties. For the next seven years minimum base prices for the uranium-oxide content of carnotite-roscoelite type ores of the Colorado plateau will be increased from the present range of $.50 to $2 per lb up to $1.50 to $3.50, depending on grade of ore.

- **Export regulations on nonferrous ores, metals and** alloys have been tightened again. On Mar. 8, certain lead and manufactures, nickel and manufactures, tin and manufactures, and other nonferrous ores were added to the Government list requiring proof that the material proposed for export actually is available to the applicant. Such factors as the over-all amount available for export, end-use of exports, and ultimate destination are considered. See Current Export Bulletin No. 611 for further details.

- **A second Wemco prefabricated Heavy-Media** separation plant has been ordered for the Shook & Fletcher Supply Co.'s Warner mine near Russellville, Ala. Using a 6x5-ft Wemco drum separator, the plant will beneficiate about 70 tph of 3x⅛-in. brown iron ore. The company has had two years of successful operation with a No. 4M Wemco Mobil-Mill (see MINING ENGINEERING, December 1950).

- **Rich copper deposits in the Gaspe Peninsula will** be developed by Noranda Mines Ltd., with the company authorizing expenditure of $12 to $15 million for the purpose. Copper deposits thus far examined give promise of a century of operations there.

- **Calumet & Hecla's new Shullsburg, Wis., lead**-zinc mine is now producing about 650 tons of ore per day. Production is expected to increase to about 1200 tons per day by the middle of this year.

- **The Vanadium Corp. of America will more than** double its production of metallurgical chrome ore as a result of the purchase of properties in Southern Rhodesia by its subsidiary, Rhodesian Vanadium Corp. The new facilities were acquired as a going property, complete with mine cars, rails, dumps, water supplies, and housing. This acquisition will provide practically all of the company's chrome ore requirements.

CARBIDE INSERT BITS

a two-year test led to adoption of carbide insert bits at the Iron King mine. Results: greater production, lower costs, and happier miners.

by A. J. ZINKL

AFTER more than two years of test work on various types of bits, the Iron King mine of the Shattuck-Denn Mining Co. has definitely settled on the tungsten carbide insert bit. This test work included more than a million and a quarter ft of drilling and the destruction of over 8000 insert bits.

Ore at the mine is a tough, cherty, highly abrasive sulphide. Some of the rock is so hard to drill that as little as 1 in. of advance was made per steel bit-use. This rock, however, is the exception as the average over the entire mine, including development in schist, is about 16 in. per steel bit-use. The 3⅛-in., 120-lb stoper and the 3½-in. power-fed drifter were used in the tests.

This paper concerns itself with the analysis of Table I, on the next page. During the test periods production was increased about 40 pct; the mining method was changed from shrinkage to horizontal cut and fill; annual wage increases were granted; and to further complicate the statistics, there was a change from carbon steel drill rods to alloy steel rods. All these factors influence a true comparison of the cost and production figures.

The statistics are grouped under three headings. Those under column B were intentionally included to show the results of the original closely supervised preliminary tests as compared to those figures under column C, which are the figures representing operations for the last five months. Test results do not always hold true in operations, and it is necessary to check operating figures against the sometimes optimistic test figures.

A five-month production period was used to collect the data for each of these sets of figures. In analyzing them there are four important ones to be noted.

First, the 48 tons of ore produced per drill-shift with insert bits over the 32 tons previously produced with steel bits is the most significant figure. It represents an increase from 56,000 tons in five months to 86,000 tons in the same period of time, with virtually the same number of drill-shifts. This increase can be credited directly to the insert bit. This was managed with no additional investment in drilling equipment; without having to increase compressor capacity; and with no increase in supervisory personnel. To obtain this tonnage increase with steel bits it would have been necessary to make comparable additions in service departments and change-house facilities, and would have meant additional payroll and other personnel problems. Other considerations in favor of adoption of the insert bit at the Iron King mine are such intangibles as less rock drill maintenance and repair, the handling of fewer bits, and the consumption of less air per hole drilled. The decrease in tons mined per ft of hole drilled from 0.59 tons to 0.48 tons would indicate a disadvantage in drilling with the insert bits, and would further indicate more holes drilled, signifying higher

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powder consumption. This, however, is only partly true. The mining and ore handling method was changed from shrinkage stoping to cut-and-fill stoping using scrapers. In the latter method the miners have to slush the broken ore and are therefore more careful to obtain good fragmentation.

The second noteworthy comparison is that the figures on bit and steel reconditioning show an increase to 7 tons per bit-use with carbide bits as compared to 1 ton per bit-use with steel bits, and an increase to 93 tons per steel failure with alloy steel as compared to the previous 39 tons with carbon steel. These results add up to less work in the blacksmith shop. The Iron King operation is using nickel alloy steel made to Ingersoll-Rand specification No. 139, and putting threads on this steel. First attempts to thread the steel were unsuccessful, but today the steel moves through the shop as smoothly as did the carbon drill steel. Handling fewer bits and less drill steel effected a 25 pct cut in blacksmith shop labor, which is a saving of about 3c per ton for reconditioning. When using steel bits about 7500 bits were sharpened per month and over 300 pieces of steel reconditioned. Now approximately 2100 insert bits are refaced monthly and only 185 pieces of alloy steel are reworked. It must be remembered that this numerical decrease was achieved despite a tonnage boost. Insert bits are refaced about five and one half times. During preliminary tests each bit was resurfaced eight times. This drop indicates that the bits are being used harder and drilled longer. There is a point reached in drilling where the bit should be refaced, and any footage drilled over that point detracts from the optimum footage available out of a bit. This, in part, accounts for the decrease in tonnage realized per new bit, which under column B was 9.9 tons, and under present conditions is only 7 tons.

The third figure to be noted is the drop in drilling cost from 50c per ton to 36c per ton. This saving was effected despite the fact that wages were increased twice during the two-year period. Here again the good results can be credited to the use of the carbide bit. The wage increase of $1.03 per shift from $11.13 to $12.16 was more than offset by the additional tonnage. The miners were able, with wage increases and bonus payments, to raise their daily wages to $1.61 per shift. Actually the value of the insert bit to the men is in the comparison of the bonus payments of $5.86 per shift in column B over the $4.66 in column A. This $1.20 which went into the miner's pockets is again attributable to the insert bit. During the course of subsequent wage negotiations after this bonus pattern had been established, the $1.20 was split with the miners. It was necessary to recover part of the higher supply cost and the miners agreed to dividing the bonus increase rather than return to detachable steel bits.

The enthusiastic reception of this bit-and-steel combination by the drillers is understandable. The bonus system is based on cu ft of ore mined in the stopes, and ft of advance in the raises, drifts, and shaft. The men were the best salesmen for the bit. In addition to the faster drilling, they were able to spend more time drilling, had fewer bits to carry into the stopes, they did not have to change bits with each steel run, and were really doing less work. At one time two stope miners tried to set a record with these bits during the initial test work. They each drilled forty-five 6½-ft holes in one shift for the unheard of total of 580 ft of hole, or about 275 tons of ore drilled and blasted. The record still stands. An attempt was made to keep development work in the schist hanging wall on steel bits. This, however, proved unsatisfactory as the men offered to buy the insert bits themselves.

The fourth significant figure is on the higher cost side. This is the 30c per ton cost for steel and bit supplies. This cost is even higher when the bits alone are considered. The initial cost of the nickel alloy steel is about 30 pct higher than carbon steel, but with 150 pct better results an over-all steel cost reduction of approximately 35 pct was obtained. This consideration makes the cost of insert bits appear out of line. The increase in bit supply cost over the bit cost during preliminary test work is a problem now being corrected. This cost increase is the result of three conditions: (1) the increase in the supply of bits on hand; (2) harder use of the bits; and (3) theft and loss in mine.

The question of why bits are eventually discarded is important, as some remedial steps may be taken to help obtain maximum footage. An accurate record was kept of 100 bits; the tabulation of the results are expressed in percentages on the bottom

Table I

Shattuck Denn Mining Corp.

Iron King Mine

Bit and Steel Data

Basic Statistics	A	B	C
Type of bit	Detachable steel	Carbide insert	Carbide insert
Type of drill steel	Carbon	Nickel alloy	Nickel alloy
Size of bit	2⅛ in. starter	1⅝ in.	1⅝ in.
Production period	5 mo. 1948	5 mo. 1949	5 mo. 1950
Tonnage mined	55865	56961	85733
Footage drilled	94545	104980	178635
Drilling shifts	1722	1325	1791
Bits			
New	16844	643	1889
Reconditioned	38686	5105	10339
Total bit uses	55530	5748	12228
Steel failures	1428	587	923
Wages (with overtime)	$11.13	$11.77	$12.16
Bonus (with overtime)	4.66	5.86	5.24
Total drilling wages per shift	15.79	17.63	17.40
Tonnage Statistics			
Tons/ft drilled	.59	.54	.48
Tons/drilling shift	32.00	43.06	48.00
Tons/bit use	1.00	9.90	7.00
Tons/steel failure	39.00	97.00	93.00
Cost per Ton Statistics			
Steel and bits			
Supplies	$.14	$.20	$.30
Shop labor	.07	.06	.04
Total	.21	.26	.34
Drilling cost			
Wages	.35	.27	.25
Bonus	.15	.14	.11
Total	.50	.41	.36
Total cost	.71	.67	.70

Analysis of Bit Failures	Percent
Insert face failure	61
Worn threads	18
Broken skirts	7
Excessive gage loss	7
Lost in mine or stolen	7

of the data sheet. As is evident, most of the bits were no longer usable because of insert face failure and inserts broken or knocked out of the slots. If one insert or opposite inserts are out, it is possible to continue drilling, but if adjacent inserts are out, the bit must be discarded. The next highest percentage reveals that bit threads were worn to a point where the bit would not hold to the steel and had to be discarded. However, when thread wear was the reason for discarding the bits, the inserts were often in poor shape, so that it was questionable whether or not more footage was available. Attempts were made to fit these bits with oversize threads and prepared steel with matching oversize threads, but the additional footage realized was not sufficient to make this procedure a standard practice. Welding the bit to a piece of drill steel also proved unsatisfactory. Seven pct of the bits are discarded because of gage loss. An over-all average gage loss of 0.001 in. per ft of hole drilled has been noted, but some rock is more abrasive and caused gage loss up to 0.002 in. per ft of hole. This rock accounts for the 7 pct that are discarded for gage loss. Of these bits, more footage would be possible, as both the insert and the threads are still in good shape, but the bit diameter has been reduced to where the steel binds in the hole.

The bits that are discarded because of skirt breakage or fracture again involve judgment as to whether or not more footage was available. Often the breakage is only slightly ahead of face failure. The seven pct lost in the mine or stolen is not a good figure. It calls for better supervisory and supply control. The miners are required to check in all bits, regardless of condition, and to have these used bits replaced with new bits. This works well in theory but does not account for all the reasons a miner can create for having lost a bit in the mine.

In conducting this test work an attempt was made to cover all the possibilities with insert bits. Initial attempts were made with the chisel-type bit. It was learned that this bit was subjected to rapid gage loss and not adaptable to the ground. In all instances the chisel bits were discarded for gage loss but still had excellent inserts and good threads.

Work with the regular four-point bit was more satisfactory. However, the first bits tried showed that the gradual taper from the base of the insert to the bottom of the skirt did not permit rapid removal of the drillings. Both Timken and Ingersoll-Rand then designed a bit that was cut away sharply just below the insert. The design is called a "fast breaking wing" and is ideally suited to drilling at Iron King. This type of bit is Ingersoll's 115XCS4 and Timken's MCA 1⅝ CS, both 1⅝-in. bits. Experimental work with 1½-in. bits showed better drilling speed and better steel life, but gage loss due to abrasion was such that full advantage of the carbide inserts could not be taken before the bits were sticking in the hole.

The one-use bit has been tested. It produced remarkable figures both in drilling speed and footage drilled, but the difficulty of removal from the drill rods and the greater number of bits needed to drill the ground did not equal the footage per shift produced by the insert bits. Consequently, with the miners sold on the insert bits, it was impossible to get a favorable response from the men. Also, there was some skepticism concerning the number of used and possibly unused bits that would show up in the ore flow from the stopes to the crusher.

The nickel alloy drill steel used at Iron King was made for use with the Ingersoll-Rand jackstud. It is, however, being threaded at this mine. Round 1¼-in. drifter steel and 1-in. quarter octagon stoper steel is being employed.

On thread fabrication the steel is heated to 2200 or 2300°F and is upset. After cooling, it is reheated to 1900 to 2000°F and packed in flake mica to anneal for easy threading. After being threaded on a high speed 2-in. Toledo threader, the steel is heated for hardening to between 1550 and 1650°F in a slow fire (this should take about 15 or 20 min). When the steel is up to heat it is cooled for 4 or 5 min in a forced air drift which has a velocity of about 2000 fpm. The steel is then placed in a rack, thread end up, for finished cooling. It will then be at a temperature of 450 to 500°F and the remaining heat acts as a draw.

On shank fabrication the method is similar. The steel is heated to between 2200 and 2300°F and shanked. The shank is then hardened in two steps. In the first step it is heated to between 1550 and 1650°F and is air cooled until cold. The second step is to reheat the last ½ to ¾ in. of the shank end in a fast fire to between 1500 and 1550°F and then the whole shank is quenched in oil.

Much of the additional footage per steel failure was due to the decrease in the bit diameter, and not entirely attributable to the change from carbon to alloy steel. Results per steel failure are expressed in tons on the data sheet, but the footage figures are equally impressive. With carbon steel and the 2⅛-in. starter steel bit 77 ft of drilling per steel failure were obtained. The changes to alloy steel and the 1⅝-in. insert bit led to 193 ft per steel failure.

Two small scale tests were conducted to determine the additional footage which could be credited to the new alloy steel and that which could be credited to the smaller bit diameter. The first test employed 2⅛-in. steel bits on alloy steel, and the second test 1⅝-in. insert bits on carbon steel rods. It was found that approximately 50 pct of the additional footage resulted from the smaller bit diameter, and 50 pct from the change to alloy steel rods.

Most of the failures now are at the thread end of the rod, due either to worn threads, or breakage at or near the threads. With alloy steel there is section breakage per 3000 ft of drilling.

Bits are refaced manually, and in such a way that the refaced bit simulates the face on a new bit. A bench grinder which has an 8-in. green grit, 60-grain, vitrified bond, silicon-carbide grinding wheel is now in use. An average of about 100 refacing jobs per grinding wheel has been maintained.

Several problems still need correcting. New rock-drill purchases are toward a lighter, faster-hitting machine; grinding practice is shortly going to be with a 12-in. wheel rather than the present 8-in. wheel; and control of the bits is being tightened.

It is felt that drilling costs can be further reduced, but the management at Iron King notes with satisfaction that the present 70c per ton cost would today have been about 85c with steel bits.

Acknowledgments

The helpful suggestions of H. F. Mills, manager, Iron King mine, Joe Tomkinson, of the Ingersoll-Rand Co., and James Kaess, of the Timken Co. are hereby gratefully acknowledged.

Northwest Industrial Minerals

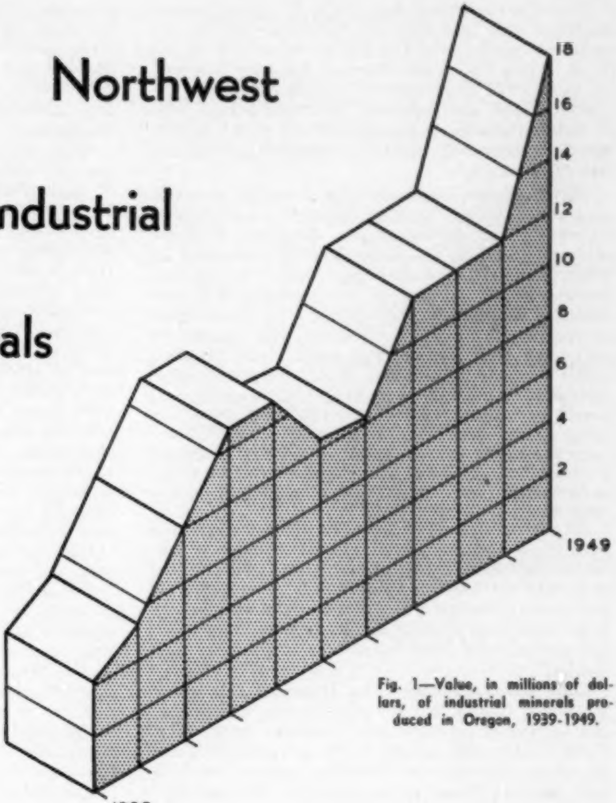

Fig. 1—Value, in millions of dollars, of industrial minerals produced in Oregon, 1939-1949.

the rich Columbia River Basin is producing a long list of minerals useful in ceramics, farming, construction, power, metallurgy, and other industries.

by A. O. BARTELL and R. S. MASON

THE industrial economy of the Lower Columbia River Basin for the past 100 years can be summed up with the logger's cry of TIMBER! Today the crash of falling trees can still be heard but the sound comes less frequently and from a greater distance. Western Oregon and Washington have used wood and wood products for houses and heat, to build ships and bridges, to support power and telephone lines on miles of poles, and in some cases to pave roads with logs and planks. More recently plywood, laminated trusses, and pulp and paper have become firmly established. Today sawdust, limbs, bark, and other tree wastes are finding their way into products such as alcohol, plastics, hardboard, cork, chemicals, and many others.

In such a resinous atmosphere the industrial minerals industry has grown slowly. As the area became settled and the habits of the populace more settled, the demand for permanent building materials increased. Brick and tile kilns preceded the opening of quarries for building stone which later yielded to monolithic and precast concrete structures. Roads slowly tied the towns and cities of the vast Oregon territory together with thousands of yards of road metal. A transcontinental railroad reached the lower Columbia in 1884, the first step toward putting the area on the industrial minerals map. Diatomaceous earth deposits came into production more than 25 years ago and the processed material was shipped to all parts of the country. Scattered limestone deposits furnished stone to cement kilns located as far as 300 miles distant. The past decade has witnessed the steadily increasing production of lightweight aggregates, both natural and artificial.

Fig. 1 clearly shows the upward trend of the value of industrial minerals in Oregon for the past 10 years. Dollar values give the graph a distorted upward sweep over the years, but the tonnage produced has increased steadily also.

The magnitude and diversity of industrial minerals consumption in the area at the present time is shown in Table I, P. 317.

The list is far from complete. It could be detailed *ad infinitum* to include the consumption of such things as poultry grits and pharmaceutical mixtures. It is believed, however, that the tabulation does serve to indicate the magnitude of the consumption of the industrial minerals and their major role in a complex, expanding industrial economy.

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Those interested in how such a tabulation was compiled will note that the references include not only the usual sources of information such as the U. S. Bureau of Mines Mineral Industry Surveys, I.C.C. reports, and technical papers on specific industries, but also personal communications with friends within the industries. These personal contacts are extremely helpful in assembling information of this type.

Clay Products—An abundance of readily available clay and cordwood assured the early establishment of a brick and tile industry in the area. With one or two exceptions the industry is characterized by rather small plants serving local communities. Sometimes the brickyards are equipped with obsolescent equipment and operated by descendants of the original founder. Normally the plants are noncompetitive among themselves. All of them suffer from the importation, often from considerable distances, of products whose chief consumer appeal would seem to be the enchantment in the great distance it had been shipped to market. High heat-duty fire bricks are not produced locally and must be imported. Suitable clay for refractories exists at Hobart Butte in Lane County, Ore., but there has been no production.

An interesting development in the past year has been the successful use of ground perlite as a substitute for feldspar in a ceramic glaze.[1] Substitution of perlite for feldspar could result in considerable savings to manufacturers of stoneware and pottery in the area since there is no local source of feldspar. The use of other glass substitutes is a further possibility.[2]

Lime and Limestone—The abundant rainfall of the lower Columbia indirectly assures a continual and increasing production of limestone in the area. Flood control and power dams annually consume enormous quantities of Portland cement which in turn requires limestone. Aside from this one type of construction, which will create regional shortages of cement for several years, there has been a steady increase in the amounts of concrete placed in industrial and domestic buildings. Rainfall on the croplands in the area creates an additional demand for limestone. Leached valley soils require large amounts of agrock to correct soil acidity, supply calcium for plant tissues, and improve the tilth of the soil. As a farmer prospers so does the supplier of agricultural limestone. In good times farmers buy soil conditioners, mainly ground limestone, but drop out of the market during poor times. Active soil conservation service programs under which the federal government spreads limestone on farms have done much to increase the tonnage used. Only a small fraction of the amount of agricultural stone that should be used is now being applied to the soils, however, because of high cost. There exists in the area an acute distribution problem. For best results agricultural limestone should be applied immediately prior to the planting season. Unfortunately soils are usually too wet to support heavy spreading equipment. During the short time available there is not enough spreading equipment to meet the demand. A lack of sufficient distribution points located so as to provide a maximum 20-mile truck haul to farms further complicates the problem.

High quality limestone is used extensively by the pulp and paper and carbide industries.

One of the major voids in a supply of industrial minerals for the area has been a local source of chemical grade lime. In the past as much as 25,000 tons per year have been shipped in from as fas east as Missouri. This void will soon be filled, however, if present plans materialize. U. S. Lime Products has announced the intention of constructing a $1,500,000 lime burning plant on Portland waterfront property. It is the Company's announced intention to mine and barge limestone from Kosciusko Island, Edna Bay, Alaska. The Kosciusko deposit

Fig. 2—Multi-million dollar Dantore lightweight plaster aggregate and acoustical tile plant on the Deschutes River in eastern Oregon.

Table I. Industrial Minerals Consumption in Oregon and Southern Washington

INDUSTRIES	INDUSTRIAL MINERALS USED	TONS CONSUMED PER YEAR*	REF.	SOURCE	REMARKS
AGRICULTURE					
Soil Supplements	Limestone	60,000-80,000	7	Local	Five producers in Oregon, 1950.
	Gypsum	5,000	7	Western U.S.	
	Sulphur	2,500	7	Gulf states	
BUILDING MATERIALS					
Aggregates	Sand and gravel	11,000,000	10	Local	Half of this amount commercial production; half for Gov't projects.
	Expanding shale	38,000	4	Local	Production will be greater in future because of recent capacity increase.
	Pumice	170,000 yd	6	Local	Six producers in Oregon, 1950.
	Perlite	9,560	3	Local	500,000—3 cu ft bags of aggregate produced; 560 tons produced for acoustical tile.
Cement	Limestone	230,000	3	Local	Three plants in Oregon. Production 2,100,000 bbl cement.
	Clay and pozzuolana	160,000	3	Local	
Brick & tile	Clay	120,000	5	Local	10 plants in Oregon—38 million bricks.
Roofing	Fillers	E	3	Local	Three plants active—all in Portland.
	Granules	E	3	Some local	
	Mica	D	3	Eastern U.S.	
	Asbestos	B	3	Eastern U.S.	
Insulation	Mineral wool rocks	D	3	Local	One active plant in the area.
ELECTRO-PROCESS					
Aluminum	Alumina from bauxite	400,000	1	Midwest & Gulf	Three aluminum reduction plants in area at present time.
	Carbon	120,000	1	Some local	
	Fluorides	15,000	1	Midwest & offshore	
Calcium Carbide	Lime	35,000	2	Local & Midwest	Two plants in Portland. One has captive limestone operation and kilns; the other imports lime from Midwest.
	Carbon	20,000	1	Some local	
Silicon Carbide	Silica	D	3	Washington	
	Carbon	D	3	Local	Lampblack from gas plant.
Ferro-Silicon	Silica rock	10,000	3	Washington	
Caustic Chlorine	Salt	40,000	1	California	
FABRICATED METALS					
Foundry	Lime	200	2	Varies	
	Silica sand	10,000-15,000	9	Midwest	
	Bentonite	200-400	3	Wyoming	
PETROLEUM PRODUCTS					
Oil gas manufacture	Residual fuel oil	2,500,000 bbl	8	California	Light oils, tars, and industrial carbon are by-products of this operation.
	Iron oxide	850	3	Local	
	Soda ash	350	3	California	
PULP & PAPER	Limestone	100,000	1	Local	
	Lime	35,000	1	Local	
	Kaolin	25,000	1	Georgia	
	Sulphur	75,000	1	Gulf	
	Salt cake	40,000	1	California	
	Soda ash	5,000	1	California	
	Alum	10,000	3	Local	Locally produced from Surinam and Arkansas bauxite.
	Titanium pigment	1,500	1	Eastern U.S.	
	Talc	3,500	1	Local	
	Dolomite	1,900	3	California	
PAINT	Talc	C	3		A paper on this industry will be presented at the AIME Northwest Industrial Minerals Conference, April 27-28.
	Diatomite	C	3		
	Mica	B	3		
	Mineral pigments	C	3		
	Silica	B	3		
	Barite	B	3		
	Clay	B	3		
	Asbestos	C	3		
	Whiting	C	3		

* Where actual consumption figures are not known or are regarded confidential, the following estimate key is used: A, 1 to 10 tons; B, 10 to 100 tons; C, 100 to 1000 tons; D, 1000 to 10,000 tons; E, 10,000 to 100,000 tons; F, in excess of 100,000 tons.

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is a phenomenally high grade limestone with proven reserves measured in cubic miles.

Lightweight Aggregates—The production of lightweight aggregate in the Northwest got off to a flying start about 6500 years ago when several volcanoes in the Cascade Range erupted explosively. Vast deposits of pumice were created in a comparatively short time. Demand for the material was slow in developing and a few hundred years later the Vulcan Mountain Building Co. went into receivership. World War II shipbuilding activities on the coast created a housing shortage at a time when most of the standard building materials were unobtainable. Precast concrete masonry units using pumice furnished a solution to the problem. Almost overnight dozens of pumice block plants of all sizes sprang up. One entrepreneur even set up his mail order block machine in his basement and lifted each freshly cast block out through a window. The inevitable result of the rush was a rash of improperly cast blocks. Poor aggregate sizing, incorrect mixes, lack of testing, insufficient curing, and other factors contributed to the failures. Consumer appeal was understandably dampened and the reappearance of regular building materials on the market curtailed pumice production drastically. Pumice aggregate producers responded by improving their product. Both crushing and screening equipment were installed and block producers began to tighten down on their production techniques. Excessive shrinkage still remains a problem that is being tackled on two Northwest campuses. Washington State College Institute of Technology and Oregon State College are both trying to preshrink the blocks in their laboratories. Not all pumice goes into precast blocks. Some is used in monolithic pours and for loose fill insulation. Granular pumice is used for chicken coop litter and by florists as a bedding material. Newest development is the production of plaster aggregate which is lighter than sand and stronger than perlite. A few carloads of abrasive grade pumice are shipped annually from Newberry Crater in central Oregon.

Lightweight plaster aggregate and acoustical tile are being manufactured in the multi-million dollar Dantore plant on the banks of Oregon's Deschutes River. See Fig. 2, P. 316.

Perlite production in the Northwest started in 1945 with a pilot popping plant located at St. Helens, Oregon. At the start only plaster aggregate, loose fill insulation, and florist's bedding material were produced. An insulating wallboard is now being manufactured in a plant adjacent to the mine and mill in central Oregon. The term "perlite" has been adopted by industry for the popped material as well as the rock from which it is produced. Several deposits of perlite occur in the Northwest but the geographic location of most of them with respect to transportation is poor.

Newest competitor in the lightweight aggregates field in the Lower Columbia Basin is expanded shale. Two producers located about 40 miles northwest of Portland supply the area. A blue-gray fossiliferous shale is used by both plants. One operator digs and bloats the shale at the quarry site. The second producer ships the raw shale to Portland where it is furnaced in a kiln adjacent to the company-owned block plant. The rotary, oil-fired kiln is said to be the largest of its kind in use, 100 ft long by 8 ft in diam. Expanded shale from the two plants is used chiefly in precast concrete blocks, with lesser tonnages going into monolithic concretes.

Fig. 3—In this plant, now being built, the Orr Chemical & Engineering Co. will fine grind Scappoose limonite. Principal use for this material is in scrubbing tanks to remove sulphur from petroleum gas.

To a certain extent expanded shale has invaded markets served formerly by pumice. Concrete blocks made with expanded shale have higher crushing strengths and less shrinkage than those made with pumice. Pumice blocks are lighter and are said to have greater fire resistance.

Sand and Gravel—The sand and gravel business generally excites but little interest, even in the ranks of industrial minerals people. Most of the sand and gravel produced in western Oregon and Washington is dredged from stream beds either by draglines on the bank or by barge-mounted equipment. Strangely enough there is a shortage in some district of good sources of road metal. Along the coast deposits of stone suitable for jetty construction are also scarce.

The biggest news in the sand and gravel business locally has been the rapid development in processing aggregates for large monolithic concrete dams. Close attention to proper gradation of aggregate sizes and correct mixes is nothing new to the industry, and the problem of reactive silica in some aggregates when used with certain cements has been given much attention recently. Latest wrinkle added to the list is temperature control of all the constituents going into concrete.[3] At Detroit Dam, Army Engineers specified a temperature range from 40°F to 50°F for concrete when freshly poured. A large refrigeration plant has been built at the damsite for this purpose.

Silica—A classic example of an inferior product meeting with greater acceptance than one of superior merit is found at one of the area's silica producers. The producer has developed a thriving poultry grit business which at first, however, developed financial difficulties due to an interesting problem. His crushed silica was admirably suited for the purpose. It was hard and pure and clean, and the price was right. There was only one thing wrong with it. It was too good. Once a chicken's crop was full of grit it required no more for the rest of its life. It just never wore out. This was unfortunate for two reasons. First, the amount of grit required for a flock was very small, and second, the poultry raisers, noting the small consumption, reasoned that the chickens didn't like it. Sales dwindled until one happy day when the producer hit on the idea of marketing crushed granite grit.

Granite grit is a rather poor grinding medium, and chickens must keep charging their pebble mills continually. Farmers are happy, because chickens eat up tons of it and the silica producer smiles every time he has eggs for breakfast.

Diatomite—Diatomite in the Lower Columbia Basin has been produced by one large producer in Oregon and two in Washington. There are numerous deposits of large size and excellent grade scattered over the eastern portion of the area. Several of these are favorably situated near raildoads and will doubtless one day be worked. The deposits in Oregon have been described by Moore,[4] those in Washington by Skinner et al.[5]

Limonite—Oregon's limonite iron ores at Scappoose (Fig. 3) have held the attention of would-be iron industrialists for over 50 years. Oregon still has no iron and steel industry based on these deposits, but they are now the source of supply for a growing industrial minerals industry. Domestic gas is manufactured for the area by the Portland Gas & Coke Co., using California residual fuel oil as a base. To rid the gas of the last remnants of sulphur before it is piped into the city lines, it is passed through scrubbing tanks that contain activated iron oxide.

In the past the major source of supply of this material has been Belgium. Officials of the gas company and others have talked about using the near-at-hand Scappoose limonite for this purpose for years, but nothing was done until a year ago when the Orr Engineering and Chemical Co. put in a pilot plant at Scappoose, Oregon. According to gas company officials, the pilot plant product is far superior to any previous source of material. A full-scale treatment plant is now being constructed on the same site at Scappoose. A total of about 900 tons of crude limonite are shipped annually to the Bay area for paint pigment.

Coke—High grade metallurgical coke has been in particularly short supply in this area in the last several years. Recent work by the U. S. Bureau of Mines and the Portland Gas & Coke Co. indicates that much of this demand could be satisfied by lampblack, a by-product from Gasco's oil-gas operation. Heretofore the lampblack, which contains 13 pct volatiles, 88 pct fixed carbon on a dry basis, and only a trace of ash, has been briquetted and sold on the domestic fuel market in competition with other heating materials. It now appears that these same briquets, calcined to drive off the moisture and volatile material, will in some respects exceed the chemical and structural specifications of metallurgical coke.

Bauxite—Large reserves of ferruginous bauxite have been drilled out in northwestern Oregon and southwestern Washington. Utilization will depend on availability of electric power and the basic economics of operation. Smaller tonnages of gibbsite which contain higher percentages of Al_2O_3 than the bauxite occur near Salem, Oregon. This material is suitable for the manufacture of refractories and abrasives but so far none has been used. Mining would present a problem in that the nodules and boulders are scattered through a flat lying zone several feet thick just below the surface. Recovery of the lumps would resemble a potato digging operation.

As the Pacific northwest develops industrially, mineral producers and the industrial consumers would benefit if there was more understanding of specifications. It is not enough to know what mineral is used in the industrial process; it is essential to know the chemical tolerances, especially in regard to the trace elements, the size and particle shape of the material and particularly what function the raw material serves in the process. Too often a supplier in attempting to secure a contract for locally produced materials will be told by the purchasing agent that his company requires the equivalent of the XYZ Company's No. 7 or some other meaningless trade name. For example, if an industrial minerals entrepreneur was conducting a market survey to determine the feasibility of developing and equipping a talc mine, it would not be sufficient to know that the insecticide industry uses X tons per year ground to pass Y mesh. He needs to know that particle shapes are a critical consideration, and just as important, that the Ph of material must be within a certain range to be compatible with chemicals that are added.

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Fig. 4—A new glaze using local volcanic glass is examined by A. O. Bartell, R. S. Mason and F. W. Libbey. The pottery will be on display at the Northwest Industrial Minerals Conference to be held in Portland Apr. 27 and 28. Bartell is managing engineer of the Raw Materials Survey and Libbey is the director of the Oregon Dept. of Geology and Mineral Industries. Both organizations are giving assistance to the conference of which Mason is chairman.

Ore Sampling at Castle Dome

by J. J. SPENCER

IT has been found that, during any particular period of operation or in mining any particular area of the Castle Dome mine, there appears a variation between mine grade and mill grade, thus far always in the plus direction. It would be interesting to know if this condition obtains at other properties, and, if possible, to alter the sampling methods or computations in order to get better agreement between mine and mill figures.

On the 4220 level 5,009,541 tons of ore were mined and milled, represented by 1945 blasthole assays. The mill grade showed an increase over the average of the blasthole assays of 8.49 pct. The 4175 level yielded 5,864,477 tons of ore which was sampled by 2161 blastholes. The corresponding mill grade showed an increase of 8.80 pct.

The yearly percentages by which mill grade assays exceed mine grade assays on approximately four million tons of ore per year are shown in Table I.

Table I. Percent by which Mill Assays Exceed Mine Assays

Year	Percent
1944	1.00
1945	6.75
1946	8.65
1947	6.68
1948	11.73
1949	14.96
1950 (9 months)	13.34

In arriving at a mine grade, the average of the blasthole assays in each shot is applied against the tonnage mined from that shot. Each hole is sampled to the level of the bench below, or approximately 45 ft, and the sample represents from 2000 to 4500 tons of ore, depending on the character of the ground. On each churn drill there is a mud box and splitter which takes a 1/12 cut out of each bailing by means of a single slot in the bottom of the launder. When the hole is down to grade, this retained 1/12 fraction is then cut in a Jones splitter to approximately 1 gal of sludge.

In order to check on the accuracy of the sampling methods, some experimental sampling was done during October 1950, working with the regular blastholes on two levels of the mine. The cuttings from each hole were cut to 1/12 and then split in the usual way. The 11/12 reject was automatically split by a three-riffle prospect splitter and then cut by hand in the Jones splitter to convenient size. This "reject", as it was called, was then assayed for comparison with the regular sample. Thus, in the reject, practically the entire sample was being run through multi-slot riffles. The results were as follows: In eight holes on the 4130 level the reject assays averaged about 2 pct less than the regular sample assays. In seven holes on the 4040 level the average of the reject assays was about 2 pct more than the average of the regular sample assays. Considering all fifteen holes, the reject assay varied from the regular assay by only ½ pct.

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The possibility was considered that values were being lost in the bottom of the hole because of the use of a dart valve bailer. If the jigging action of the tools could concentrate the values at the bottom of the column of sludge in the hole, the assay would be low because the bottom foot of hole is never touched by the bailer. Accordingly, samples were taken of a series of holes, using a flat valve bailer to get a sample of sludge from the bottom of each hole, after the regular sample had been taken with a dart valve bailer. Comparison of the assays gave the following figures: In 16 holes on the 4130 level, the average of assays from the flat valve bailer was 0.740 compared to 0.679 for the average of the regular samples, or about 9 pct more. The ore mineral in this area is chalcocite, mostly disseminated, but also in local segregations. In 19 holes on the 4040 level, the flat valve bailer gave an average of 0.539 compared to a regular sample average of 0.549, about 2 pct less. In this end of the mine the ore mineral is mostly disseminated chalcopyrite. Evidently some concentration in the sludge column does take place in the chalcocite area, but not in the chalcopyrite area. Since the chalcocite area accounts for only a small percentage of the total ore tonnage, it would seem that concentration in the bottom of the hole could account for only part of the difference in grade.

The experiments described above indicated that the sampling methods were adequate. It was then thought that, since the final grade figure is based upon pounds of recovered copper, the difference in grades might be caused by an error in determining tonnage. Mine tonnage is obtained in the following manner: The area mined during the month is surveyed and plotted. The remaining area on the level is then planimetered and the dry tonnage is calculated, using a factor of 12.5 cu ft per ton. This amount is subtracted from the corresponding figure for the previous month, giving the tonnage mined during the month. The result is checked by direct planimetering of the area mined. Use of the remaining area in this way avoids the accumulation of errors from month to month. Ore delivered to the mill during the month is weighed and calculated to dry tons and this figure is accepted as the final ore tonnage. Subtracting the ore tonnage from the total mined tonnage gives the final waste tonnage.

This method has given uniform results. However, an investigation was in order. The mill weightometers were checked and found to be accurate. In order to check the 12.5 cu ft factor used in arriving at mine tonnage, a specific gravity determination was run. Ten samples of rock were used, five from the east end of the mine and five from the west end. These samples weighed approximately 20 lb each. The average of the east end samples, after correcting for moisture, gave a specific gravity of 2.556 and a factor of 12.568 cu ft per ton, the west end samples a specific gravity of 2.581 or 12.445 cu ft per ton. The over-all average was 12.507 cu ft per ton.

powder consumption. This, however, is only partly true. The mining and ore handling method was changed from shrinkage stoping to cut-and-fill stoping using scrapers. In the latter method the miners have to slush the broken ore and are therefore more careful to obtain good fragmentation.

The second noteworthy comparison is that the figures on bit and steel reconditioning show an increase to 7 tons per bit-use with carbide bits as compared to 1 ton per bit-use with steel bits, and an increase to 93 tons per steel failure with alloy steel as compared to the previous 39 tons with carbon steel. These results add up to less work in the blacksmith shop. The Iron King operation is using nickel alloy steel made to Ingersoll-Rand specification No. 139, and putting threads on this steel. First attempts to thread the steel were unsuccessful, but today the steel moves through the shop as smoothly as did the carbon drill steel. Handling fewer bits and less drill steel effected a 25 pct cut in blacksmith shop labor, which is a saving of about 3c per ton for reconditioning. When using steel bits about 7500 bits were sharpened per month and over 300 pieces of steel reconditioned. Now approximately 2100 insert bits are refaced monthly and only 185 pieces of alloy steel are reworked. It must be remembered that this numerical decrease was achieved despite a tonnage boost. Insert bits are refaced about five and one half times. During preliminary tests each bit was resurfaced eight times. This drop indicates that the bits are being used harder and drilled longer. There is a point reached in drilling where the bit should be refaced, and any footage drilled over that point detracts from the optimum footage available out of a bit. This, in part, accounts for the decrease in tonnage realized per new bit, which under column B was 9.9 tons, and under present conditions is only 7 tons.

The third figure to be noted is the drop in drilling cost from 50c per ton to 36c per ton. This saving was effected despite the fact that wages were increased twice during the two-year period. Here again the good results can be credited to the use of the carbide bit. The wage increase of $1.03 per shift from $11.13 to $12.16 was more than offset by the additional tonnage. The miners were able, with wage increases and bonus payments, to raise their daily wages to $1.61 per shift. Actually the value of the insert bit to the men is in the comparison of the bonus payments of $5.86 per shift in column B over the $4.66 in column A. This $1.20 which went into the miner's pockets is again attributable to the insert bit. During the course of subsequent wage negotiations after this bonus pattern had been established, the $1.20 was split with the miners. It was necessary to recover part of the higher supply cost and the miners agreed to dividing the bonus increase rather than return to detachable steel bits.

The enthusiastic reception of this bit-and-steel combination by the drillers is understandable. The bonus system is based on cu ft of ore mined in the stopes, and ft of advance in the raises, drifts, and shaft. The men were the best salesmen for the bit. In addition to the faster drilling, they were able to spend more time drilling, had fewer bits to carry into the stopes, they did not have to change bits with each steel run, and were really doing less work. At one time two stope miners tried to set a record with these bits during the initial test work. They each drilled forty-five 6½-ft holes in one shift for the unheard of total of 580 ft of hole, or about 275 tons of ore drilled and blasted. The record still stands. An attempt was made to keep development work in the schist hanging wall on steel bits. This, however, proved unsatisfactory as the men offered to buy the insert bits themselves.

The fourth significant figure is on the higher cost side. This is the 30c per ton cost for steel and bit supplies. This cost is even higher when the bits alone are considered. The initial cost of the nickel alloy steel is about 30 pct higher than carbon steel, but with 150 pct better results an over-all steel cost reduction of approximately 35 pct was obtained. This consideration makes the cost of insert bits appear out of line. The increase in bit supply cost over the bit cost during preliminary test work is a problem now being corrected. This cost increase is the result of three conditions: (1) the increase in the supply of bits on hand; (2) harder use of the bits; and (3) theft and loss in mine.

The question of why bits are eventually discarded is important, as some remedial steps may be taken to help obtain maximum footage. An accurate record was kept of 100 bits; the tabulation of the results are expressed in percentages on the bottom

Table I

Shattuck Denn Mining Corp.

Iron King Mine

Bit and Steel Data

Basic Statistics	A	B	C
Type of bit	Detachable steel	Carbide insert	Carbide insert
Type of drill steel	Carbon	Nickel alloy	Nickel alloy
Size of bit	2¼ in. starter	1⅝ in.	1⅝ in.
Production period	5 mo. 1948	5 mo. 1948	5 mo. 1950
Tonnage mined	55808	56961	85733
Footage drilled	94545	104980	178635
Drilling shifts	1722	1325	1791
Bits			
New	1084	643	1899
Reconditioned	38686	5105	10329
Total bit uses	55530	5748	12228
Steel failures	1428	587	923
Wages (with overtime)	$11.13	$11.77	$12.16
Bonus (with overtime)	4.66	5.86	5.24
Total drilling wages per shift	15.79	17.63	17.40
Tonnage Statistics			
Tons/ft drilled	.59	.54	.48
Tons/drilling shift	32.00	43.00	48.00
Tons/bit use	1.00	9.90	7.00
Tons/steel failure	39.00	97.00	93.00
Cost per Ton Statistics			
Steel and bits			
Supplies	$.14	$.20	$.30
Shop labor	.07	.06	.04
Total	.21	.26	.34
Drilling cost			
Wages	.35	.27	.25
Bonus	.15	.14	.11
Total	.50	.41	.36
Total cost	.71	.67	.70

Analysis of Bit Failures	Percent
Insert face failure	61
Worn threads	18
Broken skirts	7
Excessive gage loss	7
Lost in mine or stolen	7

of the data sheet. As is evident, most of the bits were no longer usable because of insert face failure and inserts broken or knocked out of the slots. If one insert or opposite inserts are out, it is possible to continue drilling, but if adjacent inserts are out, the bit must be discarded. The next highest percentage reveals that bit threads were worn to a point where the bit would not hold to the steel and had to be discarded. However, when thread wear was the reason for discarding the bits, the inserts were often in poor shape, so that it was questionable whether or not more footage was available. Attempts were made to fit these bits with oversize threads and prepared steel with matching oversize threads, but the additional footage realized was not sufficient to make this procedure a standard practice. Welding the bit to a piece of drill steel also proved unsatisfactory. Seven pct of the bits are discarded because of gage loss. An over-all average gage loss of 0.001 in. per ft of hole drilled has been noted, but some rock is more abrasive and caused gage loss up to 0.002 in. per ft of hole. This rock accounts for the 7 pct that are discarded for gage loss. Of these bits, more footage would be possible, as both the insert and the threads are still in good shape, but the bit diameter has been reduced to where the steel binds in the hole.

The bits that are discarded because of skirt breakage or fracture again involve judgment as to whether or not more footage was available. Often the breakage is only slightly ahead of face failure. The seven pct lost in the mine or stolen is not a good figure. It calls for better supervisory and supply control. The miners are required to check in all bits, regardless of condition, and to have these used bits replaced with new bits. This works well in theory but does not account for all the reasons a miner can create for having lost a bit in the mine.

In conducting this test work an attempt was made to cover all the possibilities with insert bits. Initial attempts were made with the chisel-type bit. It was learned that this bit was subjected to rapid gage loss and not adaptable to the ground. In all instances the chisel bits were discarded for gage loss but still had excellent inserts and good threads.

Work with the regular four-point bit was more satisfactory. However, the first bits tried showed that the gradual taper from the base of the insert to the bottom of the skirt did not permit rapid removal of the drillings. Both Timken and Ingersoll-Rand then designed a bit that was cut away sharply just below the insert. The design is called a "fast breaking wing" and is ideally suited to drilling at Iron King. This type of bit is Ingersoll's 115XCS4 and Timken's MCA 1⅝ CS, both 1⅝-in. bits. Experimental work with 1½-in. bits showed better drilling speed and better steel life, but gage loss due to abrasion was such that full advantage of the carbide inserts could not be taken before the bits were sticking in the hole.

The one-use bit has been tested. It produced remarkable figures both in drilling speed and footage drilled, but the difficulty of removal from the drill rods and the greater number of bits needed to drill the ground did not equal the footage per shift produced by the insert bits. Consequently, with the miners sold on the insert bits, it was impossible to get a favorable response from the men. Also, there was some skepticism concerning the number of used and possibly unused bits that would show up in the ore flow from the stopes to the crusher.

The nickel alloy drill steel used at Iron King was made for use with the Ingersoll-Rand jackstud. It is, however, being threaded at this mine. Round 1¼-in. drifter steel and 1-in. quarter octagon stoper steel is being employed.

On thread fabrication the steel is heated to 2200 or 2300°F and is upset. After cooling, it is reheated to 1900 to 2000°F and packed in flake mica to anneal for easy threading. After being threaded on a high speed 2-in. Toledo threader, the steel is heated for hardening to between 1550 and 1650°F in a slow fire (this should take about 15 or 20 min). When the steel is up to heat it is cooled for 4 or 5 min in a forced air drift which has a velocity of about 2000 fpm. The steel is then placed in a rack, thread end up, for finished cooling. It will then be at a temperature of 450 to 500°F and the remaining heat acts as a draw.

On shank fabrication the method is similar. The steel is heated to between 2200 and 2300°F and shanked. The shank is then hardened in two steps. In the first step it is heated to between 1550 and 1650°F and is air cooled until cold. The second step is to reheat the last ½ to ¾ in. of the shank end in a fast fire to between 1500 and 1550°F and then the whole shank is quenched in oil.

Much of the additional footage per steel failure was due to the decrease in the bit diameter, and not entirely attributable to the change from carbon to alloy steel. Results per steel failure are expressed in tons on the data sheet, but the footage figures are equally impressive. With carbon steel and the 2⅛-in. starter steel bit 77 ft of drilling per steel failure were obtained. The changes to alloy steel and the 1⅝-in. insert bit led to 193 ft per steel failure.

Two small scale tests were conducted to determine the additional footage which could be credited to the new alloy steel and that which could be credited to the smaller bit diameter. The first test employed 2⅛-in. steel bits on alloy steel, and the second test 1⅝-in. insert bits on carbon steel rods. It was found that approximately 50 pct of the additional footage resulted from the smaller bit diameter, and 50 pct from the change to alloy steel rods.

Most of the failures now are at the thread end of the rod, due either to worn threads, or breakage at or near the threads. With alloy steel there is section breakage per 3000 ft of drilling.

Bits are refaced manually, and in such a way that the refaced bit simulates the face on a new bit. A bench grinder which has an 8-in. green grit, 60-grain, vitrified bond, silicon-carbide grinding wheel is now in use. An average of about 100 refacing jobs per grinding wheel has been maintained.

Several problems still need correcting. New rock-drill purchases are toward a lighter, faster-hitting machine; grinding practice is shortly going to be with a 12-in. wheel rather than the present 8-in. wheel; and control of the bits is being tightened.

It is felt that drilling costs can be further reduced, but the management at Iron King notes with satisfaction that the present 70c per ton cost would today have been about 85c with steel bits.

Acknowledgments

The helpful suggestions of H. F. Mills, manager, Iron King mine, Joe Tomkinson, of the Ingersoll-Rand Co., and James Kaess, of the Timken Co. are hereby gratefully acknowledged.

Northwest Industrial Minerals

the rich Columbia River Basin is producing a long list of minerals useful in ceramics, farming, construction, power, metallurgy, and other industries.

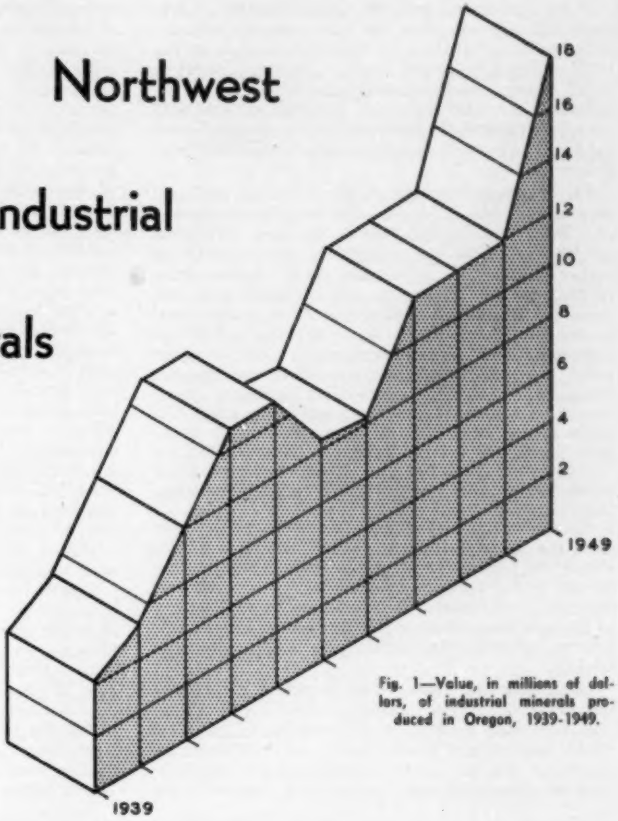

Fig. 1—Value, in millions of dollars, of industrial minerals produced in Oregon, 1939-1949.

by A. O. BARTELL and R. S. MASON

THE industrial economy of the Lower Columbia River Basin for the past 100 years can be summed up with the logger's cry of TIMBER! Today the crash of falling trees can still be heard but the sound comes less frequently and from a greater distance. Western Oregon and Washington have used wood and wood products for houses and heat, to build ships and bridges, to support power and telephone lines on miles of poles, and in some cases to pave roads with logs and planks. More recently plywood, laminated trusses, and pulp and paper have become firmly established. Today sawdust, limbs, bark, and other tree wastes are finding their way into products such as alcohol, plastics, hardboard, cork, chemicals, and many others.

In such a resinous atmosphere the industrial minerals industry has grown slowly. As the area became settled and the habits of the populace more settled, the demand for permanent building materials increased. Brick and tile kilns preceded the opening of quarries for building stone which later yielded to monolithic and precast concrete structures. Roads slowly tied the towns and cities of the vast Oregon territory together with thousands of yards of road metal. A transcontinental railroad reached the lower Columbia in 1884, the first step toward putting the area on the industrial minerals map. Diatomaceous earth deposits came into production more than 25 years ago and the processed material was shipped to all parts of the country. Scattered limestone deposits furnished stone to cement kilns located as far as 300 miles distant. The past decade has witnessed the steadily increasing production of lightweight aggregates, both natural and artificial.

Fig. 1 clearly shows the upward trend of the value of industrial minerals in Oregon for the past 10 years. Dollar values give the graph a distorted upward sweep over the years, but the tonnage produced has increased steadily also.

The magnitude and diversity of industrial minerals consumption in the area at the present time is shown in Table I, P. 317.

The list is far from complete. It could be detailed *ad infinitum* to include the consumption of such things as poultry grits and pharmaceutical mixtures. It is believed, however, that the tabulation does serve to indicate the magnitude of the consumption of the industrial minerals and their major role in a complex, expanding industrial economy.

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Those interested in how such a tabulation was compiled will note that the references include not only the usual sources of information such as the U. S. Bureau of Mines Mineral Industry Surveys, I.C.C. reports, and technical papers on specific industries, but also personal communications with friends within the industries. These personal contacts are extremely helpful in assembling information of this type.

Clay Products—An abundance of readily available clay and cordwood assured the early establishment of a brick and tile industry in the area. With one or two exceptions the industry is characterized by rather small plants serving local communities. Sometimes the brickyards are equipped with obsolescent equipment and operated by descendants of the original founder. Normally the plants are noncompetitive among themselves. All of them suffer from the importation, often from considerable distances, of products whose chief consumer appeal would seem to be the enchantment in the great distance it had been shipped to market. High heat-duty fire bricks are not produced locally and must be imported. Suitable clay for refractories exists at Hobart Butte in Lane County, Ore., but there has been no production.

An interesting development in the past year has been the successful use of ground perlite as a substitute for feldspar in a ceramic glaze.[1] Substitution of perlite for feldspar could result in considerable savings to manufacturers of stoneware and pottery in the area since there is no local source of feldspar. The use of other glass substitutes is a further possibility.[3]

Lime and Limestone—The abundant rainfall of the lower Columbia indirectly assures a continual and increasing production of limestone in the area. Flood control and power dams annually consume enormous quantities of Portland cement which in turn requires limestone. Aside from this one type of construction, which will create regional shortages of cement for several years, there has been a steady increase in the amounts of concrete placed in industrial and domestic buildings. Rainfall on the croplands in the area creates an additional demand for limestone. Leached valley soils require large amounts of agrock to correct soil acidity, supply calcium for plant tissues, and improve the tilth of the soil. As a farmer prospers so does the supplier of agricultural limestone. In good times farmers buy soil conditioners, mainly ground limestone, but drop out of the market during poor times. Active soil conservation service programs under which the federal government spreads limestone on farms have done much to increase the tonnage used. Only a small fraction of the amount of agricultural stone that should be used is now being applied to the soils, however, because of high cost. There exists in the area an acute distribution problem. For best results agricultural limestone should be applied immediately prior to the planting season. Unfortunately soils are usually too wet to support heavy spreading equipment. During the short time available there is not enough spreading equipment to meet the demand. A lack of sufficient distribution points located so as to provide a maximum 20-mile truck haul to farms further complicates the problem.

High quality limestone is used extensively by the pulp and paper and carbide industries.

One of the major voids in a supply of industrial minerals for the area has been a local source of chemical grade lime. In the past as much as 25,000 tons per year have been shipped in from as fas east as Missouri. This void will soon be filled, however, if present plans materialize. U. S. Lime Products has announced the intention of constructing a $1,500,000 lime burning plant on Portland waterfront property. It is the Company's announced intention to mine and barge limestone from Kosciusko Island, Edna Bay, Alaska. The Kosciusko deposit

Fig. 2—Multi-million dollar Dantore lightweight plaster aggregate and acoustical tile plant on the Deschutes River in eastern Oregon.

Table I. Industrial Minerals Consumption in Oregon and Southern Washington

INDUSTRIES	INDUSTRIAL MINERALS USED	TONS CONSUMED PER YEAR*	REF.	SOURCE	REMARKS
AGRICULTURE					
Soil Supplements	Limestone	60,000-80,000	7	Local	Five producers in Oregon, 1950.
	Gypsum	5,000	7	Western U.S.	
	Sulphur	2,500	7	Gulf states	
BUILDING MATERIALS					
Aggregates	Sand and gravel	11,000,000	10	Local	Half of this amount commercial production; half for Gov't projects.
	Expanding shale	30,000	4	Local	Production will be greater in future because of recent capacity increase.
	Pumice	170,000 yd	6	Local	Six producers in Oregon, 1950.
	Perlite	9,560	3	Local	500,000—3 cu ft bags of aggregate produced; 560 tons produced for acoustical tile.
Cement	Limestone	230,000	3	Local	Three plants in Oregon. Production 2,100,000 bbl cement.
	Clay and pozzuolana	100,000	3	Local	
Brick & tile	Clay	120,000	5	Local	19 plants in Oregon—20 million bricks.
Roofing	Fillers	E	3	Local	Three plants active—all in Portland.
	Granules	E	3	Some local	
	Mica	D	3	Eastern U.S.	
	Asbestos	B	3	Eastern U.S.	
Insulation	Mineral wool rocks	D	3	Local	One active plant in the area.
ELECTRO-PROCESS					
Aluminum	Alumina from bauxite	400,000	1	Midwest & Gulf	Three aluminum reduction plants in area at present time.
	Carbon	120,000	1	Some local	
	Fluorides	15,000	1	Midwest & offshore	
Calcium Carbide	Lime	35,000	2	Local & Midwest	Two plants in Portland. One has captive limestone operation and kilns; the other imports lime from Midwest.
	Carbon	20,000	1	Some local	
Silicon Carbide	Silica	D	3	Washington	
	Carbon	D	3	Local	Lampblack from gas plant.
Ferro-Silicon	Silica rock	10,000	3	Washington	
Caustic Chlorine	Salt	40,000	1	California	
FABRICATED METALS					
Foundry	Lime	200	2	Varies	
	Silica sand	10,000-15,000	9	Midwest	
	Bentonite	200-400	3	Wyoming	
PETROLEUM PRODUCTS					
Oil gas manufacture	Residual fuel oil	2,500,000 bbl	8	California	Light oils, tars, and industrial carbon are by-products of this operation.
	Iron oxide	850	3	Local	
	Soda ash	330	3	California	
PULP & PAPER	Limestone	100,000	1	Local	
	Lime	35,000	1	Local	
	Kaolin	25,000	1	Georgia	
	Sulphur	75,000	1	Gulf	
	Salt cake	40,000	1	California	
	Soda ash	5,000	1	California	
	Alum	10,000	3	Local	Locally produced from Surinam and Arkansas bauxite.
	Titanium pigment	1,500	1	Eastern U.S.	
	Talc	3,500	1	Local	
	Dolomite	1,900	3	California	
PAINT	Talc	C	3		A paper on this industry will be presented at the AIME Northwest Industrial Minerals Conference, April 27-28.
	Diatomite	C	3		
	Mica	B	3		
	Mineral pigments	C	3		
	Silica	B	3		
	Barite	B	3		
	Clay	B	3		
	Asbestos	C	3		
	Whiting	C	3		

* Where actual consumption figures are not known or are regarded confidential, the following estimate key is used: A, 1 to 10 tons; B, 10 to 100 tons; C, 100 to 1000 tons; D, 1000 to 10,000 tons; E, 10,000 to 100,000 tons; F, in excess of 100,000 tons.

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is a phenomenally high grade limestone with proven reserves measured in cubic miles.

Lightweight Aggregates—The production of lightweight aggregate in the Northwest got off to a flying start about 6500 years ago when several volcanoes in the Cascade Range erupted explosively. Vast deposits of pumice were created in a comparatively short time. Demand for the material was slow in developing and a few hundred years later the Vulcan Mountain Building Co. went into receivership. World War II shipbuilding activities on the coast created a housing shortage at a time when most of the standard building materials were unobtainable. Precast concrete masonry units using pumice furnished a solution to the problem. Almost overnight dozens of pumice block plants of all sizes sprang up. One entrepreneur even set up his mail order block machine in his basement and lifted each freshly cast block out through a window. The inevitable result of the rush was a rash of improperly cast blocks. Poor aggregate sizing, incorrect mixes, lack of testing, insufficient curing, and other factors contributed to the failures. Consumer appeal was understandably dampened and the reappearance of regular building materials on the market curtailed pumice production drastically. Pumice aggregate producers responded by improving their product. Both crushing and screening equipment were installed and block producers began to tighten down on their production techniques. Excessive shrinkage still remains a problem that is being tackled on two Northwest campuses. Washington State College Institute of Technology and Oregon State College are both trying to preshrink the blocks in their laboratories. Not all pumice goes into precast blocks. Some is used in monolithic pours and for loose fill insulation. Granular pumice is used for chicken coop litter and by florists as a bedding material. Newest development is the production of plaster aggregate which is lighter than sand and stronger than perlite. A few carloads of abrasive grade pumice are shipped annually from Newberry Crater in central Oregon.

Lightweight plaster aggregate and acoustical tile are being manufactured in the multi-million dollar Dantore plant on the banks of Oregon's Deschutes River. See Fig. 2, P. 316.

Perlite production in the Northwest started in 1945 with a pilot popping plant located at St. Helens, Oregon. At the start only plaster aggregate, loose fill insulation, and florist's bedding material were produced. An insulating wallboard is now being manufactured in a plant adjacent to the mine and mill in central Oregon. The term "perlite" has been adopted by industry for the popped material as well as the rock from which it is produced. Several deposits of perlite occur in the Northwest but the geographic location of most of them with respect to transportation is poor.

Newest competitor in the lightweight aggregates field in the Lower Columbia Basin is expanded shale. Two producers located about 40 miles northwest of Portland supply the area. A blue-gray fossiliferous shale is used by both plants. One operator digs and bloats the shale at the quarry site. The second producer ships the raw shale to Portland where it is furnaced in a kiln adjacent to the company-owned block plant. The rotary, oil-fired kiln is said to be the largest of its kind in use, 100 ft long by 8 ft in diam. Expanded shale from the two plants is used chiefly in precast concrete blocks, with lesser tonnages going into monolithic concretes.

Fig. 3—In this plant, now being built, the Orr Chemical & Engineering Co. will fine grind Scappoose limonite. Principal use for this material is in scrubbing tanks to remove sulphur from petroleum gas.

To a certain extent expanded shale has invaded markets served formerly by pumice. Concrete blocks made with expanded shale have higher crushing strengths and less shrinkage than those made with pumice. Pumice blocks are lighter and are said to have greater fire resistance.

Sand and Gravel—The sand and gravel business generally excites but little interest, even in the ranks of industrial minerals people. Most of the sand and gravel produced in western Oregon and Washington is dredged from stream beds either by draglines on the bank or by barge-mounted equipment. Strangely enough there is a shortage in some district of good sources of road metal. Along the coast deposits of stone suitable for jetty construction are also scarce.

The biggest news in the sand and gravel business locally has been the rapid development in processing aggregates for large monolithic concrete dams. Close attention to proper gradation of aggregate sizes and correct mixes is nothing new to the industry, and the problem of reactive silica in some aggregates when used with certain cements has been given much attention recently. Latest wrinkle added to the list is temperature control of all the constituents going into concrete.[8] At Detroit Dam, Army Engineers specified a temperature range from 40°F to 50°F for concrete when freshly poured. A large refrigeration plant has been built at the damsite for this purpose.

Silica—A classic example of an inferior product meeting with greater acceptance than one of superior merit is found at one of the area's silica producers. The producer has developed a thriving poultry grit business which at first, however, developed financial difficulties due to an interesting problem. His crushed silica was admirably suited for the purpose. It was hard and pure and clean, and the price was right. There was only one thing wrong with it. It was too good. Once a chicken's crop was full of grit it required no more for the rest of its life. It just never wore out. This was unfortunate for two reasons. First, the amount of grit required for a flock was very small, and second, the poultry raisers, noting the small consumption, reasoned that the chickens didn't like it. Sales dwindled until one happy day when the producer hit on the idea of marketing crushed granite grit.

Granite grit is a rather poor grinding medium, and chickens must keep charging their pebble mills continually. Farmers are happy, because chickens eat up tons of it and the silica producer smiles every time he has eggs for breakfast.

Diatomite—Diatomite in the Lower Columbia Basin has been produced by one large producer in Oregon and two in Washington. There are numerous deposits of large size and excellent grade scattered over the eastern portion of the area. Several of these are favorably situated near raildoads and will doubtless one day be worked. The deposits in Oregon have been described by Moore,[4] those in Washington by Skinner et al.[5]

Limonite—Oregon's limonite iron ores at Scappoose (Fig. 3) have held the attention of would-be iron industrialists for over 50 years. Oregon still has no iron and steel industry based on these deposits, but they are now the source of supply for a growing industrial minerals industry. Domestic gas is manufactured for the area by the Portland Gas & Coke Co., using California residual fuel oil as a base. To rid the gas of the last remnants of sulphur before it is piped into the city lines, it is passed through scrubbing tanks that contain activated iron oxide.

In the past the major source of supply of this material has been Belgium. Officials of the gas company and others have talked about using the near-at-hand Scappoose limonite for this purpose for years, but nothing was done until a year ago when the Orr Engineering and Chemical Co. put in a pilot plant at Scappoose, Oregon. According to gas company officials, the pilot plant product is far superior to any previous source of material. A full-scale treatment plant is now being constructed on the same site at Scappoose. A total of about 900 tons of crude limonite are shipped annually to the Bay area for paint pigment.

Coke—High grade metallurgical coke has been in particularly short supply in this area in the last several years. Recent work by the U. S. Bureau of Mines and the Portland Gas & Coke Co. indicates that much of this demand could be satisfied by lampblack, a by-product from Gasco's oil-gas operation. Heretofore the lampblack, which contains 13 pct volatiles, 88 pct fixed carbon on a dry basis, and only a trace of ash, has been briquetted and sold on the domestic fuel market in competition with other heating materials. It now appears that these same briquets, calcined to drive off the moisture and volatile material, will in some respects exceed the chemical and structural specifications of metallurgical coke.

Bauxite—Large reserves of ferruginous bauxite have been drilled out in northwestern Oregon and southwestern Washington. Utilization will depend on availability of electric power and the basic economics of operation. Smaller tonnages of gibbsite which contain higher percentages of Al_2O_3 than the bauxite occur near Salem, Oregon. This material is suitable for the manufacture of refractories and abrasives but so far none has been used. Mining would present a problem in that the nodules and boulders are scattered through a flat lying zone several feet thick just below the surface. Recovery of the lumps would resemble a potato digging operation.

As the Pacific northwest develops industrially, mineral producers and the industrial consumers would benefit if there was more understanding of specifications. It is not enough to know what mineral is used in the industrial process; it is essential to know the chemical tolerances, especially in regard to the trace elements, the size and particle shape of the material and particularly what function the raw material serves in the process. Too often a supplier in attempting to secure a contract for locally produced materials will be told by the purchasing agent that his company requires the equivalent of the XYZ Company's No. 7 or some other meaningless trade name. For example, if an industrial minerals entrepreneur was conducting a market survey to determine the feasibility of developing and equipping a talc mine, it would not be sufficient to know that the insecticide industry uses X tons per year ground to pass Y mesh. He needs to know that particle shapes are a critical consideration, and just as important, that the Ph of material must be within a certain range to be compatible with chemicals that are added.

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Fig. 4—A new glaze using local volcanic glass is examined by A. O. Bartell, R. S. Mason and F. W. Libbey. The pottery will be on display at the Northwest Industrial Minerals Conference to be held in Portland Apr. 27 and 28. Bartell is managing engineer of the Raw Materials Survey and Libbey is the director of the Oregon Dept. of Geology and Mineral Industries. Both organizations are giving assistance to the conference of which Mason is chairman.

Open-Pit Forum

Ore Sampling at Castle Dome

by J. J. SPENCER

IT has been found that, during any particular period of operation or in mining any particular area of the Castle Dome mine, there appears a variation between mine grade and mill grade, thus far always in the plus direction. It would be interesting to know if this condition obtains at other properties, and, if possible, to alter the sampling methods or computations in order to get better agreement between mine and mill figures.

On the 4220 level 5,009,541 tons of ore were mined and milled, represented by 1945 blasthole assays. The mill grade showed an increase over the average of the blasthole assays of 8.49 pct. The 4175 level yielded 5,864,477 tons of ore which was sampled by 2161 blastholes. The corresponding mill grade showed an increase of 8.80 pct.

The yearly percentages by which mill grade assays exceed mine grade assays on approximately four million tons of ore per year are shown in Table I.

Table I. Percent by which Mill Assays Exceed Mine Assays

Year	Percent
1944	1.00
1945	6.75
1946	8.65
1947	6.68
1948	11.73
1949	14.96
1950 (9 months)	13.34

In arriving at a mine grade, the average of the blasthole assays in each shot is applied against the tonnage mined from that shot. Each hole is sampled to the level of the bench below, or approximately 45 ft, and the sample represents from 2000 to 4500 tons of ore, depending on the character of the ground. On each churn drill there is a mud box and splitter which takes a 1/12 cut out of each bailing by means of a single slot in the bottom of the launder. When the hole is down to grade, this retained 1/12 fraction is then cut in a Jones splitter to approximately 1 gal of sludge.

In order to check on the accuracy of the sampling methods, some experimental sampling was done during October 1950, working with the regular blastholes on two levels of the mine. The cuttings from each hole were cut to 1/12 and then split in the usual way. The 11/12 reject was automatically split by a three-riffle prospect splitter and then cut by hand in the Jones splitter to convenient size. This "reject", as it was called, was then assayed for comparison with the regular sample. Thus, in the reject, practically the entire sample was being run through multi-slot riffles. The results were as follows: In eight holes on the 4130 level the reject assays averaged about 2 pct less than the regular sample assays. In seven holes on the 4040 level the average of the reject assays was about 2 pct more than the average of the regular sample assays. Considering all fifteen holes, the reject assay varied from the regular assay by only ½ pct.

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The possibility was considered that values were being lost in the bottom of the hole because of the use of a dart valve bailer. If the jigging action of the tools could concentrate the values at the bottom of the column of sludge in the hole, the assay would be low because the bottom foot of hole is never touched by the bailer. Accordingly, samples were taken of a series of holes, using a flat valve bailer to get a sample of sludge from the bottom of each hole, after the regular sample had been taken with a dart valve bailer. Comparison of the assays gave the following figures: In 16 holes on the 4130 level, the average of assays from the flat valve bailer was 0.740 compared to 0.679 for the average of the regular samples, or about 9 pct more. The ore mineral in this area is chalcocite, mostly disseminated, but also in local segregations. In 19 holes on the 4040 level, the flat valve bailer gave an average of 0.539 compared to a regular sample average of 0.549, about 2 pct less. In this end of the mine the ore mineral is mostly disseminated chalcopyrite. Evidently some concentration in the sludge column does take place in the chalcocite area, but not in the chalcopyrite area. Since the chalcocite area accounts for only a small percentage of the total ore tonnage, it would seem that concentration in the bottom of the hole could account for only part of the difference in grade.

The experiments described above indicated that the sampling methods were adequate. It was then thought that, since the final grade figure is based upon pounds of recovered copper, the difference in grades might be caused by an error in determining tonnage. Mine tonnage is obtained in the following manner: The area mined during the month is surveyed and plotted. The remaining area on the level is then planimetered and the dry tonnage is calculated, using a factor of 12.5 cu ft per ton. This amount is subtracted from the corresponding figure for the previous month, giving the tonnage mined during the month. The result is checked by direct planimetering of the area mined. Use of the remaining area in this way avoids the accumulation of errors from month to month. Ore delivered to the mill during the month is weighed and calculated to dry tons and this figure is accepted as the final ore tonnage. Subtracting the ore tonnage from the total mined tonnage gives the final waste tonnage.

This method has given uniform results. However, an investigation was in order. The mill weightometers were checked and found to be accurate. In order to check the 12.5 cu ft factor used in arriving at mine tonnage, a specific gravity determination was run. Ten samples of rock were used, five from the east end of the mine and five from the west end. These samples weighed approximately 20 lb each. The average of the east end samples, after correcting for moisture, gave a specific gravity of 2.556 and a factor of 12.568 cu ft per ton, the west end samples a specific gravity of 2.581 or 12.445 cu ft per ton. The over-all average was 12.507 cu ft per ton.

Informal "session" around the registration desk as the meeting opened.

AIME ANNUAL MEETING ATTRACTS OVER 2000

THE St. Louis Annual Meeting of AIME was one of the best, as the more than 2000 mining engineers who attended will attest. This was the 171st General Meeting of AIME and each of the five memorable days, Feb. 18 to 22, imparted something of knowledge, camaraderie, and festivity. The ubiquitous Howard I. Young and his competent committeemen were masters of the hundred and one problems inherent in convention management.

St. Louis Section of AIME arranged this meeting to insure maximum participation of students and young engineers. Student Associate members were not required to pay a registration fee. Smoker and Annual Banquet tickets were so divided that those desiring to pass up the dinner part of the program could come in later for the entertainment or dancing for a nominal charge. A student forum was held on Thursday afternoon so that students could question a panel, representative of all branches of the mineral industries, on career problems.

The full implications of the national emergency for the mining industry were brought sharply into focus by the more than 400 authors and speakers. Man power, atomic energy, foreign minerals, and progress in technology were discussed at 80 technical sessions; frequently there were 10 sessions going on simultaneously. On Sunday evening, S. C. Hollister, dean of engineering at Cornell University, spoke on graduate training for engineers at a session of the Mineral Industry Education Division. Interesting as this talk was, the audience would not permit Dean

Three men who had a lot to do with the success of the 171st Annual Meeting were, (l to r) Chairman of the General Committee Howard I. Young, 1950 President Donald H. McLaughlin, and 1951 President Willis M. Peirce.

ANNUAL MEETING

Council of Section Delegates held an all-day business meeting on Saturday. Those present included (front row, l to r) E. M. Thomas, D. H. Butem, A. T. Cole, L. A. Grant, J. E. Kastrop, J. M. Moore, J. A. Chrichton, W. W. Leonard, R. Schuhmann, Jr., F. T. Moyer, Secretary, (middle row l to r) R. H. Smith, J. C. Cordell, G. L. Yates, W. C. Chase, C. E. Smith, H. Strandberg, W. C. Leonard, P. D. Wilson, C. T. Holland, H. A. White, J. C. Kinnear, Jr., Carlos Bardwell, (standing l to r) H. M. Krouse, Linwood Theissen, L. J. Thronson, A. L. Jamieson, J. O. Harder, E. H. Wisser, W. A. Mueller, H. A. Dierks, M. I. Signer, E. P. Pfleider, P. P. Ribotto, G. C. Weaver, R. T. Gallagher, R. D. Chapman, F. W. Strandberg, Chairman of the meeting, and W. K. Bock.

Hollister, special advisor to the War Manpower Commission, to be seated until he had commented on the engineering manpower situation. Dean Hollister said that a critical shortage of engineers was on the way as the supply of graduates is steadily diminishing. A large percentage of engineers are in the reserves of the armed forces and Dean Hollister said that some criteria should be established to determine whether these men are more valuable in the services or in industry.

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Space does not permit mention of all the names of those responsible for this fine meeting but mention should be made of the fine performance of Fred J. Meek, Nat L. Shepard, C. W. Ambler, Jr., and Carl H. Cotteril who kept things rolling from day to day. The finance committee under the direction of Carl G. Stifel did splendid work and they and the many manufacturing and mining companies who generously contributed to finance the meeting receive the hearty thanks of AIME.

Among those attending the luncheon meeting of the Mining, Geology, and Geophysics Division were (standing) Father J. B. Macelwane, St. Louis University; J. M. Riddell, Michigan College of Mining and Technology; and (seated l to r) Sherwin F. Kelly, Chairman Geophysics Subdivision; E. D. Gardner, 1951 MGGD Chairman; and P. J. Shenon, retiring Chairman MGGD.

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Frank R. Milliken, assistant manager, titanium division, National Lead Co., received the Robert H. Richards Award at the Annual Banquet from outgoing President D. H. McLaughlin.

Geophysicists Discuss Economics, Exploration Costs

The first session of the Geophysics Subdivision, which consisted mainly of papers on the economics of geophysics, was held on Tuesday morning, with the Mineral Economics and Mining, Geology, and Geophysics Division. S. F. Kelly's paper on the economics of geophysics illustrated rather strikingly the fact that geophysics has played a very important part in increasing known mineral resources, especially in Sweden and South Africa. He stated that many orebodies had been found in Canada and the United States because of help given by geophysics but did not have complete data on the cost of geophysics in these countries to compare with the value of deposits found.

Carl A. Bays gave an interesting paper on the "Cost of Geophysical Exploration" making comparisons between the costs of various methods.

Oscar Weiss's paper on "Cost of Geophysical Prospecting for Minerals" pointed out the high overhead of a geophysical firm, thus illustrating the reasons for high fees.

Wednesday's session was taken over by the Geophysics Subdivision and meetings were well attended. However, these sessions conflicted with sessions of the geology division therefore not nearly as many geologists were in attendance as would have been if such conflicts could have been avoided. This was unfortunate in the case of the papers given by F. G. Smith, W. H. Little and A. D. Mutch on "Methods of Geothermonetry Being Developed at the University of Toronto" and the paper by Homer Jansen on "Airborne Magnetometric Explorations in the Petroleum Industry."

The writer wishes to compliment the authors on the subject matter of their papers and the committee in charge of arranging the program on its selection of papers.—**Reported by Basil T. Wilson.**

ANNUAL MEETING

Geologists Cover Broad Ground in Several Sessions

The most popular geology gathering was the joint session with the Mining Subdivision on "Geology and the Choice of Mining Methods." Organized by G. B. Clark of the University of Illinois, this group of papers was heard by over 250 members. M. S. Walker explained the adaptation of block caving to variations in the rock at Climax caused by alteration jointing and other factors. Edward Wisser set forth the numerous features of structural geology which call for different mining procedures. J. D. Bateman sent in from Giant Yellowknife a paper on operations at that mine. R. S. Loofbourow outlined the factors to be considered in laying out a mine.

Large attendance and lively discussion accompanied a series of nine papers presented at Tuesday's joint session of the Geology Subdivision and the Society of Economic Geologists. These papers covered various facets of "Surface and Near-Surface Manifestations of Orebodies."

C. L. Thornberg, formerly chief geologist of Real del Monte, discussed "Surface Expressions of Veins in the Pachuca Silver District, Mexico," emphasizing the telltale extension of alteration above the ore shoots. Harrison Schmitt, commenting on the paper, noted the use of similar features in other districts, and extended the Pachuca discussion to features characteristic of bottoms of ore shoots.

Edward Wisser, speaking from extensive experience in the Pachuca district, discussed guides to ore in that district, accenting the understanding and use of tectonic history as an exploration guide, and warning against dependence on empirical rules as ore guides. C. L. Thornberg commented on the usefulness of this concept in areas other than Pachuca.

F. S. Turneaure of the University of Michigan spoke on the character of ore shoots of the Bolivian tin deposits, pointing out their erratic vertical distribution and suggesting certain mineral assemblages that are regarded as indicative of nearby ore shoots. The nature of the plugs with which the veins are associated was discussed by Harrison Schmitt. Ira Joralemon ventured the opinion that the erratic ore shoot distribution may be a result of timing as well as pressure variations, with Dr. Turneaure favoring the latter explanation.

C. O. Swanson of the Consolidated Mining & Smelting Co. discussed the structural control of ore distribution evident on the surface and in shallow workings of the Fairview mine, Similkameen District, B. C. Lyman Huff of the Geological Survey presented a paper entitled "The Abnormal Copper, Lead, and Zinc Contents of Soil Near Metalliferous Veins," and brought up to date the increasing promise of geochemical prospecting as a useful tool in discovering concealed ore shoots. The lively discussion that followed revealed the widespread interest in this method of prospecting.

The usefulness of careful study of reasons for failure in exploration work to avoid similar situations in future explorations was accented by the Geological Survey's Arnold Brokaw. His paper was entitled "Geologic Factors Leading to Negative Results in Exploration at White Pine, Tenn."

In his paper "Outcrops in Limestones as Ore Guides", C. H. Behre, Jr. noted the need for systematic evaluation of these features in each locality to determine their relative significance in specific areas. Discussion of the various alteration phases evident

Five leading geologists seen at the Society of Economic Geologists dinner in the Hotel Jefferson. In the background, Carl Tolman, Washington University; Harold Bannerman, USGS; Edward Clark, Missouri Geological Survey. In foreground are C. H. Behre, Columbia University and John S. Brown, St. Joseph Lead.

Three of the winners of the national Student Prize Paper Contest being congratulated by President Peirce. They are (l to r) Ronald Bish, Warren P. Chernack, and Charles E. Lundin

in mineralized limestones was offered by Harrison Schmitt, P. J. Shenon, and others.

"Shallow Expressions of Silver Belt Ore Shoots, Coeur d'Alene District, Idaho" were summarized by R. E. Sorenson of the Hecla Mining Co., who outlined their daring and imaginative use in the search for deep orebodies. Discussion by M. S. Walker, T. S. Lovering, and Ira Joralemon pointed out the possible usefulness of additional study of alteration and mineralogy in the district.

P. F. Kerr of Columbia University illustrated the characteristic "Clay Alteration Associated with Uranium Mineralization" in several deposits of the United States, thus pointing out another type of deposit in which alteration haloes can enlarge the exploration target. Of importance also was the observation that the alteration zone itself exhibits considerable radioactivity. T. S. Brown and T. S. Lovering participated in the clarifying discussion.

The General Session on geology, held Wednesday afternoon, covered a broad range of interests. F. W. Farwell described the aid that geologists can provide in solving milling problems. He used examples from the flotation and sink-float processes to show the need for mineralogic identification of mill feed and mill products where chemical analysis is not sufficient for optimum efficiency.

A. F. Frederickson of Washington University presented revolutionary ideas in a paper proposing a new hypothesis concerning the origin of the Mississippi Valley lead-zinc deposits. He proposed that the metals moved in the form of cations in two stages. The first was during consolidation of the lime rocks under pressure of burial, and the second occurred if crustal movements caused a movement of the connate water. The latter stage was seen as accounting for commercial concentrations while the former stage was said to account for the widespread but non-economic concentrations of lead and zinc throughout the Mississippi Valley.

Ernest F. Ohle described the Hayden Creek lead mine in southeastern Missouri. This mine is notable because the host rock is not dolomite, but granite boulders. W. T. Stuart's paper outlined procedures for mining under a water-saturated glacial mantle.

Reno H. Sales and Charles Meyer added another paper to their list of significant contributions from Butte. This was a discussion of the post-ore rhyolite dikes which cut the ore-bearing veins in the Butte district, and the effect of their intrusion on Butte ore minerals. Pyrite-bearing chalcocite ore, typical of the Central Zone, is converted to massive bornite and chalcopyrite adjacent to the dikes. The reaction is interpreted as a duplication in nature of furnace experiments in which similar products were obtained by heating chalcocite and pyrite together in the absence of excess sulphur. It is believed that the dikes were emplaced after all of the ore had been deposited, but before the dying phases of main-stage hydrothermal activity had ceased completely.

The importance of water supplies was recognized at a Monday session in which six papers on ground water geology, mostly in the central United States, were presented. Vigorous discussion was forthcoming on the merits of geophysical versus ordinary geologic methods of making subsurface studies. Glaciology was shown to be a key feature in the search for ground water in the North Central States.

Although the attendance was limited to a faithful band of some 100 people, the most significant sessions may have been those organized by A. F. Frederickson to probe the basic scientific features of clays, bauxites and laterites in general. Twenty papers were assembled from authors as distant as Hawaii, France, and Scotland, but the emphasis was on domestic examples by American authorities. This assemblage was probably the most outstanding gathering of knowledge in the field since the laterite controversy emerged.—**Reported by Roger H. McConnel.**

Ladies activities at the meeting included the Welcoming Luncheon. From the extreme left, clockwise, we see: Mrs. A. H. Compton, Mrs. Oliver Bowles, new President of the WAAIME; Mrs. D. H. McLaughlin; Mrs. H. A. Prosser; Mrs. J. B. Haffner; Mrs. Curtis L. Wilson; Mrs. Howard I. Young; Mrs. Willis M. Peirce.

Industrial Minerals Division Active at Fourteen Sessions

The Industrial Minerals Division held 14 sessions at the Annual Meeting, four on each of the first three days and two on the last day. The 60 papers presented covered everything from mineralogy to cost accounting, and were international in scope. Joint sessions were held with the Geology Subdivision, the Society of Economic Geologists, the Mineral Economics Division, and the Mining Subdivision.

The first two sessions were devoted to the industrial minerals of Canada, having been arranged by the Program Committee through Dr. E. S. Moore, Canadian Vice-chairman of the Division. The Monday morning session was opened by Chairman R. M. Foose and Vice-chairman E. S. Moore who emphasized the importance of knowledge of the mineral resources available in neighboring countries.

The first paper, "Canada's Wealth in Industrial Minerals," by M. F. Goudge, was followed by papers on the industrial minerals of Quebec, Saskatchewan, and British Columbia, fluorspar deposits in Newfoundland, asbestos mining, and gypsum deposits in British Columbia. A paper on the discovery of potash in wells drilled for oil in Saskatchewan during the past decade elicited many questions from the audience.

The Tuesday morning sessions dealt with dimension stones and clay technology. Papers on dimension stone in California, Pennsylvania, Minnesota, and Indiana were presented, and the subject of clay technology was covered by papers on Florida phosphate slimes, ceramic investigation of Arkansas clay deposits, beneficiation of Arkansas high-iron bauxite, fluid jet pulverizers for grinding solids, and application of the shale planer in the production of industrial minerals.

In the afternoon, one session was devoted to perlite and other lightweight aggregates, including special references on the trends in Oregon, Washington, Idaho, and Kansas. The other session was a joint meeting with the Mining Subdivision and covered core drilling, blasthole drilling, and pipeline transportation of phosphates. The last mentioned paper, by Tillotson, Burt, and Barr, was much broader than its title indicated, as it included much information on the nature and uses of the material pumped and the vast areas of abandoned slimes in the phosphate areas.

The Wednesday morning papers dealt with sulphur in Argentina, synthetic mica, beryllium in industry, and Searles Lake brines in California. The last mentioned paper gave details of the methods used in the recovery of sodium carbonate, sodium sulphate, potash, borax, and bromine from the complex brines of Searles Lake. A paper on the economics of future sulphur supply in the United States, presented by William L. Suager and John D. Sullivan, was of special interest, as it showed the trend in demand and potential sources of sulphur that may be made available for chemicals and for other industries.

The seven papers presented at the joint meeting with the Society of Economic Geologists were a symposium on clay and laterite relationship and set forth the advances in clay technology, the origin of Arkansas barites, relations of hydrous aluminum oxide minerals in clay, kaolin deposits in central Georgia, and the origin and detection of cold precipitated ferric oxide in clays.

The Wednesday afternoon sessions included a joint meeting with the Mineral Economics Division and a joint meeting with the Geology Subdivision.

One of the two Thursday sessions was a joint meeting with the Mineral Economics Division, which closed with a paper by J. D. Turner on mineral leasing on Government acquired lands. It was the first paper on the subject to be presented before the AIME. Attention was called to the wide variety of minerals on acquired land and the possibilities of their development by obtaining leases through the Dept. of the Interior.

The wide range of minerals discussed in the papers presented at the meeting is too great to review here in any detail. The trend was to review resources of industrial minerals (deposits now under development and potential resources, both those known for sometime and those newly discovered), and to discuss new uses, particularly demands during the present emergency. Phases covered were deposition, character of the minerals or ores, prospecting, development, mining, preparation for use, economics, markets, potential markets, and new and expanded uses. The subject of specifications, of vital interest to all producers, was discussed but requires considerable further study because of the wide varia-

Enjoying the Industrial Minerals Division luncheon are (from far left): AIME Secretary E. H. Robie; A. B. Cummins, Chairman, Ind. Min. Div.; E. S. Moore, McIntyre Porcupine Mines; H. M. Bannerman, Eastern Vice-Chairman; J. C. Melvin, Ohio State geologist; J. L. Gillson, Director AIME; Ian Campbell, California Institute of Technology. In the foreground is R. M. Foose, retiring Chairman.

tion of the end product from deposits of similar composition and physical properties.

The international aspect of the meeting was reflected by papers on Canadian industrial minerals, sulphur in Argentina, fluorspar deposits in Mexico, and the economics of industrial minerals of Cuba.

The annual luncheon meeting at noon on Wednesday was well attended, and a large representation of the Executive Committee met at 5 pm. Mr. Foose, retiring Chairman, was enthusiastically congratulated for one of the most active years of the Division in number and quality of papers presented and in regional meetings held during his term in office, and A. B. Cummins, the incoming Chairman, was heartily welcomed.

Following the technical sessions, members enjoyed a field trip to the Pittsburgh Glass Co's. mine and plant at Crystal City, Mo.—**Reported by H. I. Smith.**

At a Coal Division session are (l to r) R. L. Anderson, Program Chairman Orville Lyons, Secretary D. R. Mitchell, and Arno Fieldner.

Coal Division Has Lively Sessions, Spirited Discussions

The Coal Division was very much in the forefront at the annual meeting. Technical sessions were lively, discussions were good, and two members—J. D. Francis of the Island Creek Coal Co., and J. B. Morrow of the Pittsburgh Consolidation Coal Co.—received gold medals at the Annual Banquet for their skill in managing large coal mining enterprises.

One new piece of mining equipment, an automatically operated series of belt conveyors, was unveiled at the Tuesday morning technical session by Clifford Snyder of the Sunnyhill Coal Co. This machine makes possible completely continuous mining of coal. Designed to operate back of the Colmol, it permits a continuous movement of coal from the face to the main transportation system of the mine. It can also be adapted to use behind other continuous mining machines or loading machines in coal, rock, and other minerals where the top size of the mined material is not too large.

Asman's and Bitner's paper, "Characteristics of Mechanized Mine Sections," presented a new approach for evaluating the performance of mechanical equipment in coal mines.

Yancey and Geer reopened the perennial question of coal washing efficiency, and are to be commended for their masterly treatment of this subject. Certainly at the top level of coal preparation master minds this paper will receive careful scrutiny. This reporter is inclined to think it is about time for precise definitions to be made as to what is meant by the various terms used in evaluating coal washers and coal washing. Certainly no such confusion exists in the other fields of mineral preparation. A start has been made, and perhaps order will emerge from the chaotic condition of methods and terms presently in use. In summary these authors state:

"Performance can be evaluated in a number of different ways, with the choice of the proper method to use being dictated by the objectives of the investigation and the data available. The performance of any cleaning unit is determined by the character of the raw coal treated, the density of the separation, and the sharpness of the separation effected between coal and impurity. Thus, three factors enter into performance; one is determined by the coal, one is dictated by market or use considerations, and one is an inherent characteristic of the cleaning unit itself.

"Efficiency, which is influenced by all three factors, measures directly the loss of salable coal and thus is the performance criterion of greatest practical value.

"Sharpness of separation is measured in terms of either error area or probable error, both of which are determined from a distribution curve for the washing operation. These criteria are useful in comparing the operation of washing units making dissimilar separations, because they are substantially independent of either the character of the raw coal or the density of separation. They must not be confused with efficiency, however, because low values of error area or probable error sometimes are accompanied by low efficiency."

Coal mine plant depreciation problems received major attention Monday with several outstanding

Notables at the Coal Division luncheon meeting are Carroll A. Garner, Chairman, James D. Francis, Island Creek Coal Co., and Carroll F. Hardy, retiring Chairman of the Division.

papers. Discussion was lively and through it all these facts seem apparent: (1) Present procedures and methods are inadequate, unsatisfactory, and certainly not in accord with the times and (2) no meeting of minds was reached as to what could be done to alleviate this condition. As a result, the Mining Committee was asked to continue the study of this problem and report back at the fall meeting of the Division. Centrifugal drying, cyclone thickening, coal geology and chemical problems received attention in the technical sessions on Wednesday. All of the papers were timely and furnished further basic knowledge for the technical men in the industry.

Carroll F. Hardy, retiring Chairman of the Division, was given a vote of thanks at the dinner meeting for a job well done during his tenure of office. Carroll A. Garner, incoming Chairman, has selected a capable corps of assistants for the year, including J. W. Woomer, Chairman of the Mining Committee, Julian Parton, Chairman of Preparation, and J. F. Barkley, Chairman of Utilization. A. Lee Barrett is Chairman Elect of the Division for 1951.

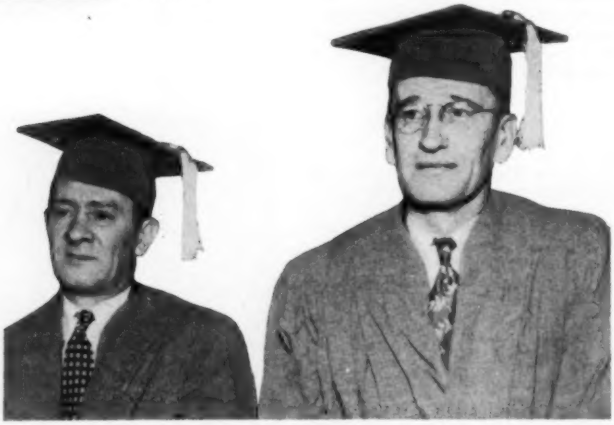
Members of the Coal Division were voluble in their expressions of pleasure at the hospitality of the coal mining fraternity of the middlewest. Visitors from afar were made to feel at home; an aura of good fellowship prevailed. Members of the Coal Division in St. Louis and surrounding areas deserve a special vote of thanks for their help.—**Reported by David R. Mitchell.**

Crowded MBD Sessions Highlight Division's Growth

The Minerals Beneficiation Division at the age of 3 years proved itself in St. Louis to be a full grown member in the family of Institute divisions. Practically all meetings including the business meeting attracted large attendance. In previous years discussions of MBD business were delayed while a quorum was sought. In St. Louis the only delay was in finding space to accommodate all members interested in participating in the meeting, thereby revealing increased interest, as well as the wisdom of moving the meeting from Sunday afternoon to Monday morning.

The Division officially resolved to participate in the Mexico City meeting, Oct. 29 to Nov. 3, with the hopes of organizing at least two technical sessions devoted to Mexican minerals beneficiation industries. The Program Committee Chairmen reported that a substantial backlog of papers exists and the Treasurer reported on the financial success in the operation of the Division. Hence, MBD appears to be in robust condition in regard to both program material for future meetings and bank account.

The first technical session was held Monday afternoon and dealt with materials handling and solid-fluid separation. It is unusual to find a coal preparation plant described at an MBD session; yet that was the case, and the subject of discussion was TCI's new plant at Concord. Several innovations both in materials handling and solid-fluid separation were described. At this session, Snavely of Chain Belt Co. presented design calculations for conveyor belts. Weems of the Dorr Co. depicted industrial installations of the DorrClone for desliming, classification at 200 mesh, and dewatering. A system for automatically controlling the underflow density was shown.



Haberdashery worn by the fun-loving MBD included Scotch Breakfast hats and mortarboards. Modeling the first are Grover J. Holt, R. E. Byler, and D. W Scott. S. J. Swainson and Mr. Holt donned professional garb to become "Mill Men of Distinction" for their efforts on behalf of the MBD.

Informal "session" around the registration desk as the meeting opened.

AIME ANNUAL MEETING ATTRACTS OVER 2000

THE St. Louis Annual Meeting of AIME was one of the best, as the more than 2000 mining engineers who attended will attest. This was the 171st General Meeting of AIME and each of the five memorable days, Feb. 18 to 22, imparted something of knowledge, camaraderie, and festivity. The ubiquitous Howard I. Young and his competent committeemen were masters of the hundred and one problems inherent in convention management.

St. Louis Section of AIME arranged this meeting to insure maximum participation of students and young engineers. Student Associate members were not required to pay a registration fee. Smoker and Annual Banquet tickets were so divided that those desiring to pass up the dinner part of the program could come in later for the entertainment or dancing for a nominal charge. A student forum was held on Thursday afternoon so that students could question a panel, representative of all branches of the mineral industries, on career problems.

The full implications of the national emergency for the mining industry were brought sharply into focus by the more than 400 authors and speakers. Man power, atomic energy, foreign minerals, and progress in technology were discussed at 80 technical sessions; frequently there were 10 sessions going on simultaneously. On Sunday evening, S. C. Hollister, dean of engineering at Cornell University, spoke on graduate training for engineers at a session of the Mineral Industry Education Division. Interesting as this talk was, the audience would not permit Dean

Three men who had a lot to do with the success of the 171st Annual Meeting were, (l to r) Chairman of the General Committee Howard I. Young, 1950 President Donald H. McLaughlin, and 1951 President Willis M. Peirce.

Council of Section Delegates held an all-day business meeting on Saturday. Those present included (front row, l to r) E. M. Thomas, D. H. Butem, A. T. Cole, L. A. Grant, J. E. Kastrop, J. M. Moore, J. A. Chrichton, W. W. Leonard, R. Schuhmann, Jr., F. T. Mayer, Secretary, (middle row l to r) R. H. Smith, J. C. Cordell, G. L. Yates, W. C. Chase, C. E. Smith, H. Strandberg, W. C. Leonard, P. D. Wilson, C. T. Holland, H. A. White, J. C. Kinnear, Jr., Carlos Bardwell, (standing l to r) H. M. Krause, Linwood Theissen, L. J. Thronson, A. L. Jamieson, J. O. Harder, E. H. Wisser, W. A. Mueller, H. A. Dierks, M. I. Signer, E. P. Pfleider, P. P. Ribotto, G. C. Weaver, R. T. Gallagher, R. D. Chapman, F. W. Strandberg, Chairman of the meeting, and W. K. Bock.

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Souvenirs were lavish and also useful. Palladium tie clasps for the men and earrings of the same material for the ladies were the favors at the Welcoming Luncheon courtesy of International Nickel. Aluminum Co. of America donated aluminum backed brushes for the smoker and the St. Joseph Lead Co. contributed a beautiful leather covered address book for the Banquet. The address book had a gold embossed AIME seal on the leather cover, and an Alnico ballpoint pen was included.

Space does not permit mention of all the names of those responsible for this fine meeting but mention should be made of the fine performance of Fred J. Meek, Nat L. Shepard, C. W. Ambler, Jr., and Carl H. Cotteril who kept things rolling from day to day. The finance committee under the direction of Carl G. Stifel did splendid work and they and the many manufacturing and mining companies who generously contributed to finance the meeting receive the hearty thanks of AIME.

Among those attending the luncheon meeting of the Mining, Geology, and Geophysics Division were (standing) Father J. B. Macelwane, St. Louis University; J. M. Riddell, Michigan College of Mining and Technology; and (seated l to r) Sherwin F. Kelly, Chairman Geophysics Subdivision; E. D. Gardner, 1951 MGGD Chairman; and P. J. Shenon, retiring Chairman MGGD.

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Frank R. Milliken, assistant manager, titanium division, National Lead Co., received the Robert H. Richards Award at the Annual Banquet from outgoing President D. H. McLaughlin.

Geophysicists Discuss Economics, Exploration Costs

The first session of the Geophysics Subdivision, which consisted mainly of papers on the economics of geophysics, was held on Tuesday morning, with the Mineral Economics and Mining, Geology, and Geophysics Division. S. F. Kelly's paper on the economics of geophysics illustrated rather strikingly the fact that geophysics has played a very important part in increasing known mineral resources, especially in Sweden and South Africa. He stated that many orebodies had been found in Canada and the United States because of help given by geophysics but did not have complete data on the cost of geophysics in these countries to compare with the value of deposits found.

Carl A. Bays gave an interesting paper on the "Cost of Geophysical Exploration" making comparisions between the costs of various methods.

Oscar Weiss's paper on "Cost of Geophysical Prospecting for Minerals" pointed out the high overhead of a geophysical firm, thus illustrating the reasons for high fees.

Wednesday's session was taken over by the Geophysics Subdivision and meetings were well attended. However, these sessions conflicted with sessions of the geology division therefore not nearly as many geologists were in attendance as would have been if such conflicts could have been avoided. This was unfortunate in the case of the papers given by F. G. Smith, W. H. Little and A. D. Mutch on "Methods of Geothermonetry Being Developed at the University of Toronto" and the paper by Homer Jansen on "Airborne Magnetometric Explorations in the Petroleum Industry."

The writer wishes to compliment the authors on the subject matter of their papers and the committee in charge of arranging the program on its selection of papers.—**Reported by Basil T. Wilson.**

ANNUAL MEETING

Geologists Cover Broad Ground in Several Sessions

The most popular geology gathering was the joint session with the Mining Subdivision on "Geology and the Choice of Mining Methods." Organized by G. B. Clark of the University of Illinois, this group of papers was heard by over 250 members. M. S. Walker explained the adaptation of block caving to variations in the rock at Climax caused by alteration jointing and other factors. Edward Wisser set forth the numerous features of structural geology which call for different mining procedures. J. D. Bateman sent in from Giant Yellowknife a paper on operations at that mine. R. S. Loofbourow outlined the factors to be considered in laying out a mine.

Large attendance and lively discussion accompanied a series of nine papers presented at Tuesday's joint session of the Geology Subdivision and the Society of Economic Geologists. These papers covered various facets of "Surface and Near-Surface Manifestations of Orebodies."

C. L. Thornberg, formerly chief geologist of Real del Monte, discussed "Surface Expressions of Veins in the Pachuca Silver District, Mexico," emphasizing the telltale extension of alteration above the ore shoots. Harrison Schmitt, commenting on the paper, noted the use of similar features in other districts, and extended the Pachuca discussion to features characteristic of bottoms of ore shoots.

Edward Wisser, speaking from extensive experience in the Pachuca district, discussed guides to ore in that district, accenting the understanding and use of tectonic history as an exploration guide, and warning against dependence on empirical rules as ore guides. C. L. Thornberg commented on the usefulness of this concept in areas other than Pachuca.

F. S. Turneaure of the University of Michigan spoke on the character of ore shoots of the Bolivian tin deposits, pointing out their erratic vertical distribution and suggesting certain mineral assemblages that are regarded as indicative of nearby ore shoots. The nature of the plugs with which the veins are associated was discussed by Harrison Schmitt. Ira Joralemon ventured the opinion that the erratic ore shoot distribution may be a result of timing as well as pressure variations, with Dr. Turneaure favoring the latter explanation.

C. O. Swanson of the Consolidated Mining & Smelting Co. discussed the structural control of ore distribution evident on the surface and in shallow workings of the Fairview mine, Similkameen District, B. C. Lyman Huff of the Geological Survey presented a paper entitled "The Abnormal Copper, Lead, and Zinc Contents of Soil Near Metalliferous Veins," and brought up to date the increasing promise of geochemical prospecting as a useful tool in discovering concealed ore shoots. The lively discussion that followed revealed the widespread interest in this method of prospecting.

The usefulness of careful study of reasons for failure in exploration work to avoid similar situations in future explorations was accented by the Geological Survey's Arnold Brokaw. His paper was entitled "Geologic Factors Leading to Negative Results in Exploration at White Pine, Tenn."

In his paper "Outcrops in Limestones as Ore Guides", C. H. Behre, Jr. noted the need for systematic evaluation of these features in each locality to determine their relative significance in specific areas. Discussion of the various alteration phases evident

Five leading geologists seen at the Society of Economic Geologists dinner in the Hotel Jefferson. In the background, Carl Tolman, Washington University; Harold Bannerman, USGS; Edward Clark, Missouri Geological Survey. In foreground are C. H. Behre, Columbia University and John S. Brown, St. Joseph Lead.

Three of the winners of the national Student Prize Paper Contest being congratulated by President Peirce. They are (l to r) Ronald Bish, Warren P. Chernack, and Charles E. Lundin

in mineralized limestones was offered by Harrison Schmitt, P. J. Shenon, and others.

"Shallow Expressions of Silver Belt Ore Shoots, Coeur d'Alene District, Idaho" were summarized by R. E. Sorenson of the Hecla Mining Co., who outlined their daring and imaginative use in the search for deep orebodies. Discussion by M. S. Walker, T. S. Lovering, and Ira Joralemon pointed out the possible usefulness of additional study of alteration and mineralogy in the district.

P. F. Kerr of Columbia University illustrated the characteristic "Clay Alteration Associated with Uranium Mineralization" in several deposits of the United States, thus pointing out another type of deposit in which alteration haloes can enlarge the exploration target. Of importance also was the observation that the alteration zone itself exhibits considerable radioactivity. T. S. Brown and T. S. Lovering participated in the clarifying discussion.

The General Session on geology, held Wednesday afternoon, covered a broad range of interests. F. W. Farwell described the aid that geologists can provide in solving milling problems. He used examples from the flotation and sink-float processes to show the need for mineralogic identification of mill feed and mill products where chemical analysis is not sufficient for optimum efficiency.

A. F. Frederickson of Washington University presented revolutionary ideas in a paper proposing a new hypothesis concerning the origin of the Mississippi Valley lead-zinc deposits. He proposed that the metals moved in the form of cations in two stages. The first was during consolidation of the lime rocks under pressure of burial, and the second occurred if crustal movements caused a movement of the connate water. The latter stage was seen as accounting for commercial concentrations while the former stage was said to account for the widespread but non-economic concentrations of lead and zinc throughout the Mississippi Valley.

Ernest F. Ohle described the Hayden Creek lead mine in southeastern Missouri. This mine is notable because the host rock is not dolomite, but granite boulders. W. T. Stuart's paper outlined procedures for mining under a water-saturated glacial mantle.

Reno H. Sales and Charles Meyer added another paper to their list of significant contributions from Butte. This was a discussion of the post-ore rhyolite dikes which cut the ore-bearing veins in the Butte district, and the effect of their intrusion on Butte ore minerals. Pyrite-bearing chalcocite ore, typical of the Central Zone, is converted to massive bornite and chalcopyrite adjacent to the dikes. The reaction is interpreted as a duplication in nature of furnace experiments in which similar products were obtained by heating chalcocite and pyrite together in the absence of excess sulphur. It is believed that the dikes were emplaced after all of the ore had been deposited, but before the dying phases of main-stage hydrothermal activity had ceased completely.

The importance of water supplies was recognized at a Monday session in which six papers on ground water geology, mostly in the central United States, were presented. Vigorous discussion was forthcoming on the merits of geophysical versus ordinary geologic methods of making subsurface studies. Glaciology was shown to be a key feature in the search for ground water in the North Central States.

Although the attendance was limited to a faithful band of some 100 people, the most significant sessions may have been those organized by A. F. Frederickson to probe the basic scientific features of clays, bauxites and laterites in general. Twenty papers were assembled from authors as distant as Hawaii, France, and Scotland, but the emphasis was on domestic examples by American authorities. This assemblage was probably the most outstanding gathering of knowledge in the field since the laterite controversy emerged.—**Reported by Roger H. McConnel.**

Ladies activities at the meeting included the Welcoming Luncheon. From the extreme left, clockwise, we see: Mrs. A. H. Compton, Mrs. Oliver Bowles, new President of the WAAIME; Mrs. D. H. McLaughlin; Mrs. H. A. Prosser; Mrs. J. B. Haffner; Mrs. Curtis L. Wilson; Mrs. Howard I. Young; Mrs. Willis M. Peirce.

ANNUAL MEETING

Industrial Minerals Division Active at Fourteen Sessions

The Industrial Minerals Division held 14 sessions at the Annual Meeting, four on each of the first three days and two on the last day. The 60 papers presented covered everything from mineralogy to cost accounting, and were international in scope. Joint sessions were held with the Geology Subdivision, the Society of Economic Geologists, the Mineral Economics Division, and the Mining Subdivision.

The first two sessions were devoted to the industrial minerals of Canada, having been arranged by the Program Committee through Dr. E. S. Moore, Canadian Vice-chairman of the Division. The Monday morning session was opened by Chairman R. M. Foose and Vice-chairman E. S. Moore who emphasized the importance of knowledge of the mineral resources available in neighboring countries.

The first paper, "Canada's Wealth in Industrial Minerals," by M. F. Goudge, was followed by papers on the industrial minerals of Quebec, Saskatchewan, and British Columbia, fluorspar deposits in Newfoundland, asbestos mining, and gypsum deposits in British Columbia. A paper on the discovery of potash in wells drilled for oil in Saskatchewan during the past decade elicited many questions from the audience.

The Tuesday morning sessions dealt with dimension stones and clay technology. Papers on dimension stone in California, Pennsylvania, Minnesota, and Indiana were presented, and the subject of clay technology was covered by papers on Florida phosphate slimes, ceramic investigation of Arkansas clay deposits, beneficiation of Arkansas high-iron bauxite, fluid jet pulverizers for grinding solids, and application of the shale planer in the production of industrial minerals.

In the afternoon, one session was devoted to perlite and other lightweight aggregates, including special references on the trends in Oregon, Washington, Idaho, and Kansas. The other session was a joint meeting with the Mining Subdivision and covered core drilling, blasthole drilling, and pipeline transportation of phosphates. The last mentioned paper, by Tillotson, Burt, and Barr, was much broader than its title indicated, as it included much information on the nature and uses of the material pumped and the vast areas of abandoned slimes in the phosphate areas.

The Wednesday morning papers dealt with sulphur in Argentina, synthetic mica, beryllium in industry, and Searles Lake brines in California. The last mentioned paper gave details of the methods used in the recovery of sodium carbonate, sodium sulphate, potash, borax, and bromine from the complex brines of Searles Lake. A paper on the economics of future sulphur supply in the United States, presented by William L. Suager and John D. Sullivan, was of special interest, as it showed the trend in demand and potential sources of sulphur that may be made available for chemicals and for other industries.

The seven papers presented at the joint meeting with the Society of Economic Geologists were a symposium on clay and laterite relationship and set forth the advances in clay technology, the origin of Arkansas barites, relations of hydrous aluminum oxide minerals in clay, kaolin deposits in central Georgia, and the origin and detection of cold precipitated ferric oxide in clays.

The Wednesday afternoon sessions included a joint meeting with the Mineral Economics Division and a joint meeting with the Geology Subdivision.

One of the two Thursday sessions was a joint meeting with the Mineral Economics Division, which closed with a paper by J. D. Turner on mineral leasing on Government acquired lands. It was the first paper on the subject to be presented before the AIME. Attention was called to the wide variety of minerals on acquired land and the possibilities of their development by obtaining leases through the Dept. of the Interior.

The wide range of minerals discussed in the papers presented at the meeting is too great to review here in any detail. The trend was to review resources of industrial minerals (deposits now under development and potential resources, both those known for sometime and those newly discovered), and to discuss new uses, particularly demands during the present emergency. Phases covered were deposition, character of the minerals or ores, prospecting, development, mining, preparation for use, economics, markets, potential markets, and new and expanded uses. The subject of specifications, of vital interest to all producers, was discussed but requires considerable further study because of the wide varia-

Enjoying the Industrial Minerals Division luncheon are (from far left): AIME Secretary E. H. Robie; A. B. Cummins, Chairman, Ind. Min. Div.; E. S. Moore, McIntyre Porcupine Mines; H. M. Bannerman, Eastern Vice-Chairman; J. C. Melvin, Ohio State geologist; J. L. Gillson, Director AIME; Ian Campbell, California Institute of Technology. In the foreground is R. M. Foose, retiring Chairman.

tion of the end product from deposits of similar composition and physical properties.

The international aspect of the meeting was reflected by papers on Canadian industrial minerals, sulphur in Argentina, fluorspar deposits in Mexico, and the economics of industrial minerals of Cuba.

The annual luncheon meeting at noon on Wednesday was well attended, and a large representation of the Executive Committee met at 5 pm. Mr. Foose, retiring Chairman, was enthusiastically congratulated for one of the most active years of the Division in number and quality of papers presented and in regional meetings held during his term in office, and A. B. Cummins, the incoming Chairman, was heartily welcomed.

Following the technical sessions, members enjoyed a field trip to the Pittsburgh Glass Co's. mine and plant at Crystal City, Mo.—**Reported by H. I. Smith.**

At a Coal Division session are (l to r) R. L. Anderson, Program Chairman Orville Lyons, Secretary D. R. Mitchell, and Arno Fieldner.

Coal Division Has Lively Sessions, Spirited Discussions

The Coal Division was very much in the forefront at the annual meeting. Technical sessions were lively, discussions were good, and two members—J. D. Francis of the Island Creek Coal Co., and J. B. Morrow of the Pittsburgh Consolidation Coal Co.—received gold medals at the Annual Banquet for their skill in managing large coal mining enterprises.

One new piece of mining equipment, an automatically operated series of belt conveyors, was unveiled at the Tuesday morning technical session by Clifford Snyder of the Sunnyhill Coal Co. This machine makes possible completely continuous mining of coal. Designed to operate back of the Colmol, it permits a continuous movement of coal from the face to the main transportation system of the mine. It can also be adapted to use behind other continuous mining machines or loading machines in coal, rock, and other minerals where the top size of the mined material is not too large.

Asman's and Bitner's paper, "Characteristics of Mechanized Mine Sections," presented a new approach for evaluating the performance of mechanical equipment in coal mines.

Yancey and Geer reopened the perennial question of coal washing efficiency, and are to be commended for their masterly treatment of this subject. Certainly at the top level of coal preparation master minds this paper will receive careful scrutiny. This reporter is inclined to think it is about time for precise definitions to be made as to what is meant by the various terms used in evaluating coal washers and coal washing. Certainly no such confusion exists in the other fields of mineral preparation. A start has been made, and perhaps order will emerge from the chaotic condition of methods and terms presently in use. In summary these authors state:

"Performance can be evaluated in a number of different ways, with the choice of the proper method to use being dictated by the objectives of the investigation and the data available. The performance of any cleaning unit is determined by the character of the raw coal treated, the density of the separation, and the sharpness of the separation effected between coal and impurity. Thus, three factors enter into performance; one is determined by the coal, one is dictated by market or use considerations, and one is an inherent characteristic of the cleaning unit itself.

"Efficiency, which is influenced by all three factors, measures directly the loss of salable coal and thus is the performance criterion of greatest practical value.

"Sharpness of separation is measured in terms of either error area or probable error, both of which are determined from a distribution curve for the washing operation. These criteria are useful in comparing the operation of washing units making dissimilar separations, because they are substantially independent of either the character of the raw coal or the density of separation. They must not be confused with efficiency, however, because low values of error area or probable error sometimes are accompanied by low efficiency."

Coal mine plant depreciation problems received major attention Monday with several outstanding

Notables at the Coal Division luncheon meeting are Carroll A. Garner, Chairman, James D. Francis, Island Creek Coal Co., and Carroll F. Hardy, retiring Chairman of the Division.

papers. Discussion was lively and through it all these facts seem apparent: (1) Present procedures and methods are inadequate, unsatisfactory, and certainly not in accord with the times and (2) no meeting of minds was reached as to what could be done to alleviate this condition. As a result, the Mining Committee was asked to continue the study of this problem and report back at the fall meeting of the Division. Centrifugal drying, cyclone thickening, coal geology and chemical problems received attention in the technical sessions on Wednesday. All of the papers were timely and furnished further basic knowledge for the technical men in the industry.

Carroll F. Hardy, retiring Chairman of the Division, was given a vote of thanks at the dinner meeting for a job well done during his tenure of office. Carroll A. Garner, incoming Chairman, has selected a capable corps of assistants for the year, including J. W. Woomer, Chairman of the Mining Committee, Julian Parton, Chairman of Preparation, and J. F. Barkley, Chairman of Utilization. A. Lee Barrett is Chairman Elect of the Division for 1951.

Members of the Coal Division were voluble in their expressions of pleasure at the hospitality of the coal mining fraternity of the middlewest. Visitors from afar were made to feel at home; an aura of good fellowship prevailed. Members of the Coal Division in St. Louis and surrounding areas deserve a special vote of thanks for their help.—**Reported by David R. Mitchell.**

Crowded MBD Sessions Highlight Division's Growth

The Minerals Beneficiation Division at the age of 3 years proved itself in St. Louis to be a full grown member in the family of Institute divisions. Practically all meetings including the business meeting attracted large attendance. In previous years discussions of MBD business were delayed while a quorum was sought. In St. Louis the only delay was in finding space to accommodate all members interested in participating in the meeting, thereby revealing increased interest, as well as the wisdom of moving the meeting from Sunday afternoon to Monday morning.

The Division officially resolved to participate in the Mexico City meeting, Oct. 29 to Nov. 3, with the hopes of organizing at least two technical sessions devoted to Mexican minerals beneficiation industries. The Program Committee Chairmen reported that a substantial backlog of papers exists and the Treasurer reported on the financial success in the operation of the Division. Hence, MBD appears to be in robust condition in regard to both program material for future meetings and bank account.

The first technical session was held Monday afternoon and dealt with materials handling and solid-fluid separation. It is unusual to find a coal preparation plant described at an MBD session; yet that was the case, and the subject of discussion was TCI's new plant at Concord. Several innovations both in materials handling and solid-fluid separation were described. At this session, Snavely of Chain Belt Co. presented design calculations for conveyor belts. Weems of the Dorr Co. depicted industrial installations of the DorrClone for desliming, classification at 200 mesh, and dewatering. A system for automatically controlling the underflow density was shown.

Haberdashery worn by the fun-loving MBD included Scotch Breakfast hats and mortarboards. Modeling the first are Grover J. Holt, R. E. Byler, and D. W Scott. S. J. Swainson and Mr. Holt donned professional garb to become "Mill Men of Distinction" for their efforts on behalf of the MBD.

At the MBD luncheon watching R. E. Byler (extreme right) accept the reins of Chairmanship from Grover J. Holt (2nd from right) are (l to r): R. J. Russell, J. C. Lokken, D. W. Scott, E. V. Daveler, E. H. Robie, and F. R. Milliken. Another MBD luncheon photo is at bottom of page.

The Tuesday morning symposium on milling equipment was one of the most popular. Many items of interest to millmen, such as a vertical screen for increased capacity on fine screening jobs, linatex rubber for covering almost any surface to prevent wear, and a shaking conveyor for installations where belts cannot be used, were described and discussed. Of particular interest was the use of silicon-carbide pump impellors and casings for applications where wear is great. In most cases the equipment or processes discussed were in the early stages of development or application and sufficient operating data were not available for a technical paper. The popularity of this session was demonstrated by the record attendance suggests that this type of symposium should occur periodically to keep operators up to date on new milling equipment developments.

The Tuesday afternoon session was the first of two sessions on concentration and proved to be an extremely interesting one. Turrall, of the Lehigh Navigation Coal Co., described a photoelectric sorter for optical fluorspar. The only physical difference between concentrate and tailing in this operation was a slight difference in refraction index.

In another paper, the utilization of heat to obtain improved concentrate grade and recovery when oleic acid was used as the collector was demonstrated as applied to specular hematite. Arbiter, in his paper, suggested the use of a single flotation "rate constant" as a means for comparing the effect of variations in ore treatment or the effectiveness of different flotation machines. A changeover from galena to ferrosilicon in the Heavy-Media plant at Mascot showed improved results. A galena operator, however, maintained that had the galena circuit been set up properly no improvement would have been noted.

Those who attended the MIT Mineral Engineering Conference, after the annual meeting in New York last year, undoubtedly remember the interesting demonstration of sorting ores by induced radioactivity. The method was shown at this meeting to be applicable by selective activation or selective detection to a large variety of minerals. Whenever slow neutron sources are produced in assembly-line quantities, the mineral engineer will have a new concentration tool to consider.

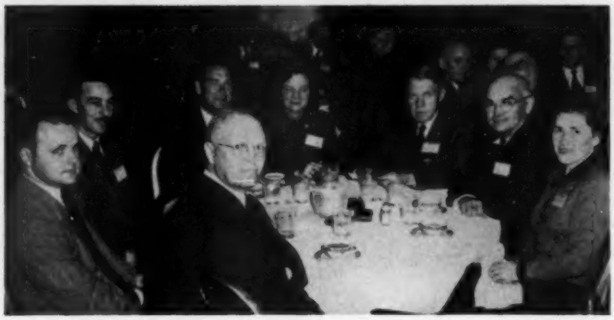
The convivial Scotch Breakfast was again a social success in spite of the fact that the Scotch lassie who added a "wee drop" of scotch to the coffee in Salt Lake was missing. Honorary chef for this affair was Ted Counselman, assisted by Herb Rose. Both chefs were regaled in chef's hats and aprons. Jack Myers suggested that for the Mexico City meeting we should have a Tequilla breakfast.

In the crushing and grinding session Wednesday morning, a stress-strain theory was tossed into the Kick-Rittenger comminution theory battle. Part of the session was also devoted to automatic devices for control of pH in phosphate flotation and remote control of pumps handling phosphate matrix.

Thursday morning's session was held jointly with the Extractive Metallurgy Division and covered such varied subjects as salt roasting and water leaching of vanadium in MacIntyre titaniferous magnetite and the flotation of gold from anode slimes in Finland.

The Annual Luncheon was a final demonstration of the Division's active growth. It was held in the same ballroom used for the smoker and the annual banquet, and although not packed to the rafters as in these latter affairs, the room was comfortably

On Mr. Byler's left are H. I. Young, W. M. Peirce, E. H. Crabtree, Jr., S. D. Michaelson, H. R. Spedden, W. B. Stephenson, Will Mitchell, Jr.



This group at the Welcoming Luncheon included: (from center, l to r) Albert Mendelsohn, Cananea Consolidated; E. H. Snyder, Jr., Combined Metals; James F. Orr, Salt Lake City; E. R. Borcherdt, Anaconda; Mrs. Borcherdt; C. E. Weed, Anaconda; Reno H. Sales, Anaconda; and Mrs. Weed.

filled. At this luncheon, past chairmen Joe Swainson and Grover Holt were inducted into the honorable order of Mill Men of Distinction as a recompense for their tireless efforts on behalf of the Division. The Charter members of this select order, Herb Rose, Ted Counselman, and Jack Myers officiated, with the assistance of Don Scott. We were privileged at the luncheon to have with us AIME President W. M. Peirce, and directors H. I. Young and E. V. Daveler. F. R. Milliken, Richards Award recipient, talked to the group on the relationship of mill and plant management. Ray Byler, the Division Chairman for 1951 introduced his associate Chairman, Ed Crabtree, and the other officers.

The clean-up gathering turned out to be a bang-up session on concentration. In addition to four scheduled papers, two papers which could not be included in the earlier sessions, were presented. All six presentations were completed with ample time for discussion through the efforts of the chairman who threatened to push the speakers off the platform if they attempted to use more than their share of the time available. Worthy of note to those who could not attend this session were two papers which were scheduled too late to be printed on the program and were preprinted too late to be included in the envelopes. These were "Microstructures in Iron Ore Pellets" by S. R. B. Cooke, and "A New Surface Measurement Tool for Mineral Engineers" by F. W. Bloecher, Jr. At this session a new theory or perhaps a physical-chemical analysis of the old theories was presented concerning the controversial subject of collector-depressant equilibria at mineral surfaces.

As the Annual Meeting closed, this weary reporter felt that the MBD sessions were enthusiastically presented and more enthusiastically received than any of the previous sessions which he has been privileged to attend.—**Reported by C. L. Sollenberger.**

MBD Features "Big Brother" Plan for Students

History was made by the student relations program of the Minerals Beneficiation Division which made a shakedown run at the St. Louis meeting. Brainchild of Donald W. Scott, the program called for a "big brother" for each student who registered with the MBD. A sign at the registration desk advised all students interested in beneficiation to leave their names so that a practicing engineer or big brother could be assigned to each registrant. The big brothers introduced the young men into MBD circles, escorted them to technical sessions, put them in touch with members who were informed on specialized subjects of interest to the students and also introduced them to prospective employers. The big brothers took the students to the Division luncheon as guests. An afternoon conference was also arranged to evaluate the program and draw suggestions from the students. The conference was a sociable affair arranged through the courtesy of Wayne L. Dowdey of Eimco and S. J. Swainson of American Cyanamid. Every Division in the Institute could profitably follow a similar program at the next Annual Meeting.

Standing left to right are student Alfred Risi, Univ. of Illinois; student R. A. Tuepker, Missouri School of Mines; John C. Lokken, Dow Chemical; Wayne L. Dowdey, Eimco and S. J. Swainson, American Cyanamid, hosts. Seated are E. C. Bitzer, Colorado Iron Works; R. C. Meaders, Carborundum; student Donald F. McCarthy, Univ. of Illinois, and student Elmer E. Thiele, Missouri School of Mines.

Students Hear Eleven Industry Leaders

APPROXIMATELY 200 students from various technical schools in the Midwest attended the student forum on "Careers in the Mineral Industry", held at Washington University's Wilson Hall on the last day of the Annual Meeting.

Dean Curtis L. Wilson of the Missouri School of Mines and Metallurgy served as Moderator at the forum with a panel of eleven prominent engineers discussing opportunities in the various branches of the industry. Evan Just of New York, Editor of *Engineering and Mining Journal*, gave the keynote address. Other members of the panel included S. S. Clarke, general superintendent, Eagle Picher Mining and Mfg. Co.; L. E. Young, consulting mining engineer; George M. Fowler, consulting geologist; W. B. Heroy, vice president, The Geotechnical Corp.; L. P. Davidson, general superintendent, electrolytic div., American Zinc Co.; Fred T. Agthe, process engineer, Allis-Chalmers Mfg. Co.; L. C. Hewitt, vice president, Laclede Christy Co.; Lloyd E. Elkins, production research director, Stanolind Oil and Gas Co.; Howard E. Butters, district manager, Joy Mfg. Co.

Mr. Just outlined the qualifications of a college graduate desired by industry, the opportunities for advancement, the draft status of the young engineer and the problem of salaries.

Mr. Clarke stressed the abilities of getting along with fellow workers and handling men as being essential requirements for success. Dr. Young pointed out that doing the kind of work one likes is necessary for proper interest and preferable to entering a distasteful field of work for salary alone. The advantages of practical experience in summer work were also pointed out by both Messrs. Clarke and Young. Dean Wilson noted that some practical experience in summer work is a requirement for graduation in several technical schools.

Questions from the floor by students included: What are the opportunities in sales engineering? What are the advantages of advanced degrees? How does the experience gained in foreign service apply in the United States? What are the opportunities in government service? What are the opportunities in teaching? Should the student remain in school as long as possible or enter the military service immediately?

Student forum speakers (standing) C. L. Wilson, L. P. Davidson, S. S. Clarke, L. C. Hewitt, H. E. Butters; seated are F. T. Agthe, L. E. Elkins, E. Just, G. M. Fowler and L. E. Young.

Mr. Butters outlined the work in sales engineering and mentioned the desirability of having college trained men in this field. Messrs. Davidson, Young, Elkins, and other members of the panel discussed the advantages of advanced degrees, agreeing that the advantages depend on the objective of the young engineer in the mineral industry. Ivan Given and M. D. Cooper covered the advantages and disadvantages of seeking practical experience before returning to college for advanced degrees. The value of foreign experience was outlined by Mr. Davidson, who answered many questions from the floor on this subject. Students were advised to stay in school as long as possible inasmuch as their contribution to the military effort will be greater as trained engineers than as servicemen.

Following the forum the students were guests of the St. Louis Section at a dinner in Nelson's Cafe.—**Reported by D. R. Schooler.**

Graduate Programs Keynote MIED Meetings

The Mineral Industry Education Division held its first sessions on Sunday afternoon and evening, Feb. 18. The meeting was held in the Jefferson Hotel in downtown St. Louis, and approximately 100 members attended. Allison Butts, Chairman of the Division, presided and opened the program by stating that the theme of the Sunday meeting was "Graduate Programs in the Field of Mineral Engineering." Informative papers directed to this general subject were offered during the afternoon by Messrs. H. H. Power, R. D. Stout, M. D. Cooper and E. P. Pfleider. Considerable discussion was elicited by each speaker.

On Sunday evening, with Associate Chairman H. H. Power presiding after dinner in the Crystal Room of the Jefferson Hotel, Lewis E. Young gave a moving eulogy of Francis A. Thomson, who died recently after serving for many years as an active member of MIED. At the conclusion of Dr. Young's citation, the assemblage stood in silent tribute to Dr. Thomson.

Dean S. C. Hollister of Cornell University was the only speaker scheduled formally on the Sunday evening program. His analysis of graduate engineering training provoked lengthy discussion by the audience. Dean Hollister also analyzed the man power situation of the country, particularly as it affects the need for academic training of engineers. He defined the problem as being one of the most serious affecting our national resource strength and he noted that in spite of all efforts to remedy the matter it has become so established as to presage a nationwide shortage of 40,000 new engineers in 1954. The consensus of all present was that such a shortage should not be permitted to continue indefinitely. A rising vote of thanks was tendered Dean Hollister at the close of the meeting.

AIME President W. M. Peirce participated informally in the general discussion.

In addition to the Sunday sessions, the Division, on Monday morning, heard papers by J. L. Bray and

W. B. Plank, while reports of respective committee activities were given by J. W. Vanderwilt and W. R. Chedsey. Dean C. J. Christensen was Chairman of the Monday session and Dean M. I. Signer served as Associate Chairman.

At the luncheon-business meeting on Tuesday, with 23 in attendance, several committee reports were offered and incidental business of the Division was transacted.

Hearty approval was given to a proposal from Chas. H. Behre, Jr. that MIED papers offered for publication, but of restricted interest, hereafter will be mimeographed and made available to anyone desiring same. This is an activity of the Publications Committee that will supplement the publication of acceptable papers of broad interest and will afford a means of disseminating the contents of many papers of a type not previously made generally available.—**Reported by J. D. Forrester.**

Variety of Methods Discussed at Mining Subdivision Sessions

Three sessions were devoted exclusively to metal mining subjects although the Subdivision held other meetings jointly with the Geology Subdivision, Geophysics Subdivision, Industrial Minerals Division, and the Mineral Economics Division. At the Tuesday morning general session, Ira B. Joralemon read the Patty paper on solar thawing of placer gravels in the Sub-Arctic which brought out the fact that stripping placer deposits in advance of dredging permitted the summer sun to thaw these deposits eliminating the need for water-thawing methods for shallow deposits (published in MINING ENGINEERING, Jan. 1951). A paper by Dale and Rundle gave an interesting description of the exploration, development, and mining operations of the Eagle-Picher Mining and Smelting Co. in the Illinois lead-zinc field. Operations there are highly mechanized like those in the Tri-State. Holes are drilled 10 ft deep with jumbo-mounted drills, loading is with crawler-mounted equipment and haulage is by Diesel trucks. Based on an extensive survey of mining operations on the Menominee Range, the Pearson and Jamar paper covered mining trends in that district. Foucault, reporting on sublevel caving of Mesabi ores, concluded that the method gives better cost per ton, a reasonably high recovery, and equivalent safety as compared to top slicing.

Tillotson, Burt, and Barr's paper on hydraulic transportation of phosphates at TVA's phosphate plant at Wilson Dam, Ala., opened the Tuesday morning joint session with the Ind. Min. Div. Seeking to avoid high transportation costs, the TVA included a hydraulic system in the design to pump phosphate concentrate as a water slurry from the mine to the finishing plant. The system has been relatively trouble free, the authors reported, with costs about $0.08 per dry ton mile, of which 50 pct is for labor, 8 pct for power, 34 pct for maintenance, and 8 pct for depreciation.

The comparatively new technique of drilling blastholes by rotary drilling methods was discussed by Samuel Leven who pointed out that it is comparable to oil field practice. The process requires a drawworks, rotary table, feeding device, and circulating medium to remove the cuttings and cool the bit. Air or liquid can be used for the circulating medium, but in the former case a dust-collection system is needed. The proper selection of circulating medium in sufficient quantities has the greatest effect on the success of drilling. In conclusion Mr. Leven pointed out that wider utilization of the method depended only on the design of bits and an extension of knowledge of the drillability of geologic formations.

Another new method of drilling that was presented was jet piercing in a paper by Fleming and Calaman. This method has been tested extensively by the Erie Mining Co. at Aurora, Minn., on the hard-drilling taconites. It has also come into some use in quarrying for both secondary breaking and primary drill holes. Holes up to 9 in. diam have been drilled by the JPM 1 in tests. Speed of piercing normal + 6-in. holes is in the neighborhood of 17 to 18 ft per hr in ground where other methods of drilling average 2 ft per hr.

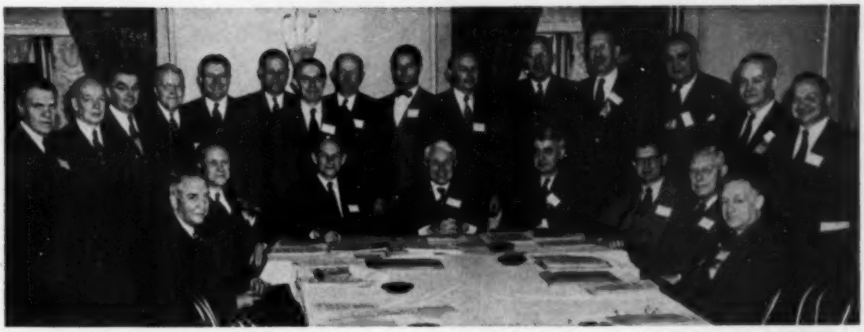
Looking ahead to the time when iron ore will be extracted from lake beds in Minnesota, James Stuart, outlined pertinent considerations in draining lakes. He emphasized the importance of an orderly system of surface drainage controls and the permanent diversion of stream flow to be controlled. Another interesting paper was one by Coil and Ross on the electrification of Miami Copper's mine at Miami, Ariz. In the early days hydroelectric power at 25 cycles was brought into the district and as mechanization and electrification increased, problems arose in the application of 25-cycle current to the many jobs in the mine. Details of the changeover made in 1947 were described.

At the business meeting following the luncheon on Tuesday of the Mining, Geology, and Geophysics Division, Philip J. Shenon, 1950 Chairman of the Division, announced the election of E. D. Gardner, Chairman of the Mining Subdivision, to head MGGD for 1951. D. M. Davidson is Geology Subdivision Chairman and Sherwin Kelly is Chairman of the Geophysics Subdivision.

Controversial Issues Interest Mineral Economists

The Mineral Economics Division held two technical sessions of its own, joined with the Industrial Minerals Division for two others, and sponsored a joint session with the Mining Geology and Geophysics Division during the St. Louis meeting. A Luncheon Meeting and a meeting of the Executive Committee rounded out the activities of the Division.

At a well attended session on Monday afternoon the foreign mineral situation was ably discussed by such outstanding authorities as Elmer Pehrson, Chester Stott, Paul Tyler and Evan Just. At other technical sessions the economics of geophysical exploration, taxation, tariffs, subsidies, cost accounting



The AIME Board of Directors meeting. Seated (l to r) E. V. Daveler, Andrew Fletcher, E. H. Robie, D. H. McLaughlin, W. M. Peirce, Harold Decker, W. E. Wrather, and Philip Kraft. Standing (l to r) C. E. Weed, Allison Butts, A. C. Rubel, N. G. Alford, C. C. Long, A. J. Phillips, E. E. Schumacher, C. V. Millikan, R. M. Foose, F. B. Foley, H. K. Work, L. E. Young, H. I. Young, G. F. Moulton, J. E. Sherborne. The Board met in open session on Feb. 18 in St. Louis at the Jefferson Hotel.

in mining, and the economics of some of the industrial minerals received attention. Evan Just suggested that the ideas and opinions expressed on taxation be assembled into a resolution and presented to the Board of Directors for their consideration as an expression of Institute policy.

Highlight of the luncheon meeting was a forum discussion of the controversial matters resolution. President McLaughlin, President-elect Peirce, Past Presidents Young and Suman, Director Gillson, Elmer Pehrson, Granville Borden, Evan Just, Paul Tyler, Arthur Blair, and Maurice Pelouhet joined in the discussion.

Messrs. McLaughlin and Peirce agreed that some issue with a minimum of controversial aspects should be presented to the Board of Directors in order to test the workability of the resolution.

The Executive Committee of the Division pledged itself to work for a strong program for the 1952 Annual Meeting and considered the possibility that some papers might be presented at the various regional meetings.—**Reported by John H. Melvin.**

Above, right, new WAAIME President Mrs. Oliver Bowles (left) with Mrs. Howard I. Young, in charge of women's activities at St. Louis. At right, President Peirce, Secretary Robie, and Elmer Pehrson of the USBM at a Mineral Economics session. Below, at Student Relations Committee luncheon (seated l to r) C. Gerow, J. D. Forrester, A. O. Dufresne, L. E. Young, M. D. Cooper, J. V. Beall, H. A. White, and T. E. Lloyd. Standing (l to r) are E. M. Thomas, C. J. Christensen, J. R. Cudworth, J. B. Haffner, P. D. I. Honeyman, Wm. R. Chedsey, T. G. Chapman, C. E. Lawall, R. D. Longyear, E. V. O'Rourke, R. E. O'Brien, R. D. Chapman, C. T. Holland, L. C. Armstrong.

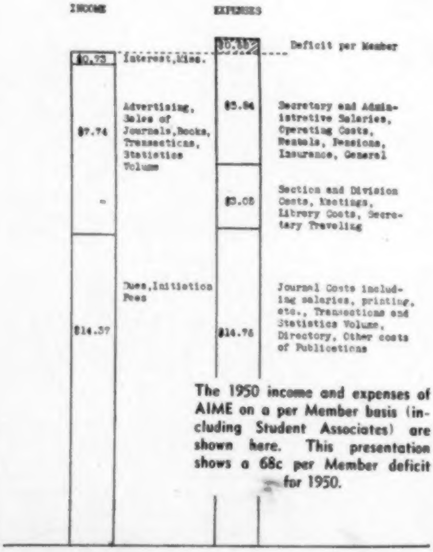
SECRETARY REPORTS AT ANNUAL MEETING

AIME FINANCIAL ANALYSIS SHOWS OPERATING LOSS OF $17,721

DURING the year 1950 AIME operations showed a net loss of $17,721. This loss was attributable entirely to the Metals Branch, the Petroleum Branch having balanced its expenses to its income and the Mining Branch having showed a net profit of $23,890. Details of the Balance Sheet are shown.

During the year, membership in the grades of Member, Associate Member, and Junior Member, showed a net increase of 844. Advertising income increased by 21 pct, the increase being almost entirely in JOURNAL OF METALS. Over-all income increased 26 pct from 1949, while expenses increased 7 pct. A preliminary budget for 1951 places income at about $2000 higher than 1950, and expenses are expected to be reduced by $28,000. Some $19,000 of this will result from the fact that no Directory will be issued in 1951.

An analysis of the financial report shows that there is an income of $22.84 per member and expenses of $23.52 per member, including Student Associate. This excludes certain items of costs that were paid for from special appropriations from accumulated income in the Barron fund. These expenses totalled $5100 or about 24c per member, bringing the total expenses per member to $23.76. A comparison of income and expense per member during 1950 is likewise shown graphically in an accompanying illustration.



The 1950 income and expenses of AIME on a per Member basis (including Student Associates) are shown here. This presentation shows a 68c per Member deficit for 1950.

INCOME AND EXPENSE STATEMENT, 1950

American Institute of Mining & Metallurgical Engineers, Inc.

	Mining Branch	Metals Branch	Petroleum Branch	Total, AIME, 12 Months
INCOME:				
Dues and Initiation Fees:	$158,444.46	$76,369.97	$75,696.11	$310,510.54
Publications:				
Advertising	54,571.95	30,390.13	18,443.42	103,405.50
Journal Sales	9,021.65	10,214.62	5,458.07	24,694.34
Transaction, Other Sales	7,293.64	7,152.03	15,002.89	29,348.56
Other Income:	11,242.71	6,464.81	8,022.94	25,730.46
Total Income	$240,574.41	$130,491.56	$122,623.43	$493,689.40
EXPENSES:				
Membership and Sections:				
Local Sections	$8,000.71	$3,754.48	$3,494.66	$15,249.85
Technical Divisions	8,933.99	13,855.34	16,159.69	38,949.02
Meeting Expenses	1,867.03	1,453.51	95.89	3,416.43
Other Expenses	10,801.86	5,274.73	4,887.75	20,964.34
Publications:				
Journals	112,896.73	101,488.59	43,315.52	257,700.84
Transactions	7,336.48	11,078.87	19,386.45	37,801.80
Directory	9,215.16	4,778.82	4,709.26	18,703.24
Other	1,512.73	1,735.44	1,929.20	5,177.37
General and Administrative:				
Salaries	22,394.87	11,000.85	9,914.86	43,310.58
Accounting	15,542.51	7,766.27	7,283.69	30,592.47
Membership	9,438.11	4,910.62	4,410.24	18,758.97
Pensions and Annuities	6,153.48	3,193.17	2,948.00	12,294.65
Insurance	239.49	122.89	113.55	475.93
Other	2,350.94	1,689.46	3,974.67	8,015.07
Total Expenses:	$216,684.09	$172,103.04	$122,623.43	$511,410.56
Profit	$23,890.32			
Loss		$41,611.48		$17,721.16

INCOME AND EXPENSE PER MEMBER, 1950

INCOME:	
Dues	$13.56
Initiation Fees	.80
Journal Advertising	4.78
Journal Sales	1.14
Transaction and Book Sales	1.52
Miscellaneous Sales	.30
Interest	.22
Miscellaneous Income	.51
Total Income, per Member	$22.84
EXPENSES:	
Journals	$11.90
Transactions, Statistics Volume	1.75
Directory	.86
Other Publications	.24
Local Section Costs	.70
Division and Branch Costs	1.80
Meeting Costs	.16
Engineering Societies Library	.30
Secretarial Traveling	.08
Administrative Salaries	2.00
Accounting Dept. Costs	1.41
Membership Dept. Costs	.87
Administrative Office Costs	.59
Pensions, Annuities	.57
Insurance, Furniture, Etc.	.26
Total Expenses, per Member	$23.52

Manufacturers News

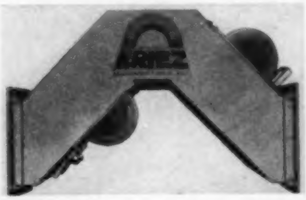
105 CFM Compressor

The new model WH-105 portable two-stage compressor is being offered by the Gardner-Denver Co. It is an all water cooled 105 cfm unit and is said to guarantee adequate rated

capacity at any altitude. Air is compressed to 28 lb in the first stage, cooled back to atmospheric temperature in an intercooler, and boosted to final discharge pressure in the second stage. An improved loader pilot operates suction unloading valves within a fixed range and automatically throttles the engine to idling speed and unloads the compressor. It is furnished on two or four wheeled spring mounted running gears. The compressor is powered by a Hercules QXD-5 6-cylinder gasoline engine, with a 230-cu in. piston displacement. **Circle No. 1**

Magnetic Hump for Removal of Tramp Iron

The Eriez magnetic hump, a product of the Eriez Mfg. Co., is designed to remove tramp iron from materials conveyed in pneumatic, gravity flow, or liquid lines. The unit consists of two Eriez magnetic separators in an enclosed rectangular sheet or cast metal housing. A "dog leg" design



takes advantage of the difference in inertia between magnetizable material and the material to be cleaned. Thus, as the iron tends to travel in a straight line, it is directed at the magnet face. Four different magnet strengths are offered,—for light applications, for removing iron within 2 in. of the magnet, and for material depths of 3 and 4 in. The Alnico magnets are guaranteed for the mechanical life of the installation. Photo illustrates the pneumatic line assembly. **Circle No. 2**

Reconditioned Thickeners

Twelve reconditioned thickeners, specially priced, are being made available by the Denver Equipment Co. These include: one 67¼ ft diam truss type equipped with angle rakes, one 60 ft diam truss type with angle rakes, three 50 ft diam truss type with angle rakes, four 40 ft diam truss types with angle rakes. All of these have truss-type superstructures and do not include tank or drive. One 28 x 8 ft deep Dorr thickener mechanism including shaft, angle rakes, drive and discharge cone is available; and two 50 x 7-ft rake type thickener mechanisms with 52-ft 6-in. steel truss superstructures including new rakes, arms and gears, reconditioned lifting device, bearings, feedwells and drive pulleys. **Circle No. 3**

New No-Rust Compound

A rust preventive of the thin film type, recommended for protection of metal surfaces against corrosion in either indoor or outdoor exposure, and known as Gulf No-Rust No. 6, is being offered by the Gulf Oil Corp. It will deposit a coating not exceeding 0.008 in. in thickness by dipping at 70°F. The coating dries within 4 hr. It will not crack, chip, scale or disintegrate at temperatures down to 0°F, nor will it flow at temperatures as high as 190°F. It can be applied by brushing, spraying or dipping and can be removed with standard solvents. **Circle No. 4**

Variable Speed Motor

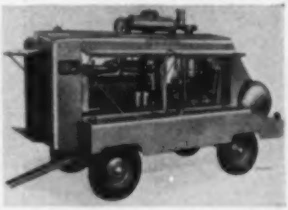
Extra heavy duty motors for variable speed, with ratings to 50 hp are offered by U.S. Electrical Motors, Inc. Dual varibelts carry the heavy load through the speed changing transmission. Tension control, to counterbalance belt load, avoids the disadvantages of variable center drives or extra flexing of belts over idlers. Change of motor speeds is accomplished by turning a control dial. **Circle No. 5**

Flammable Gas Indicator

A new explosion proof portable instrument that will disclose the presence of flammable or explosive gases is announced by the Lor-Ann Instrument Co. The company states that the instruments have been enthusiastically received by fire marshals, police officials, and others responsible for protection of lives and property. The unit is said to be explosion proof, eliminating the danger of a spark from the instrument igniting a dangerous air-vapor mixture. The Lor-Ann meter weighs 6 lb, is 5½ in. in diam, and 6½ in. high. Three controls include on-off switch, voltage check knob, and a zero setting knob. **Circle No. 6**

New Ingersoll-Rand Rotary Type Compressor

A new type large size portable air compressor, delivering 600 cfm at 100 psi, has been announced by Ingersoll-Rand. The manufacturer claims low operating cost, simplicity, lighter weight, and a discharge temperature 100°F lower than that of conventional portables. This two-stage oil-cooled rotating vane compressor eliminates pistons, con rods, valves, and the need for a clutch. Air is discharged at less than 200°F under normal conditions, thus eliminating hose de-



terioration caused by heat and oil. A General Motors Series 71 diesel drives the Gyro-Flow compressor. According to the manufacturer, the compressor is controlled smoothly over the full range from 0 to 100 pct. **Circle No. 7**

Free Literature

(8) MACHINERY CATALOG: All types of machinery manufactured by *Nordberg Mfg. Co.* are listed in brochure 187. Fully illustrated with installation and product photographs, design data is also given on 2 and 4-cycle stationary and marine diesel engines, gasoline marine engines, Symons cone crushers and screens, and mine hoists to mention a few. A description of the manufacturing facilities of the company's plants in Milwaukee and St. Louis is also included.

(9) TENSION LINKAGE: This term as used in book released by *Chain Belt Co., Baldwin Duckworth Div.*, describes any chain application in which linear movement of the chain is not continuous in direction. The predominating feature of a tension linkage is that the chain need not be an endless belt as in a power transmission drive. Numerous examples of tension linkages are shown and described. Various types of roller chains used in tension linkage applications are also illustrated and cataloged.

(10) ROBOT DOOR EQUIPMENT: A comprehensive coverage of modern automatic operating equipment for doors and gates is announced by *Robot Appliances, Inc.* Descriptive and explanatory text and the use of pictures and diagrams shows what has been done in this field in the past 20 years.

(11) WORM GEAR DRIVES: Catalog available from *Cleveland Worm & Gear Co.* illustrates various models of worm gear drives and speed reducers. These speed reducers have been serving the coal and coke industries for more than a quarter century operating shuttle cars, conveyors, separators, shakers, loaders, and other equipment.

(12) STORAGE BATTERIES: Performance and utility of storage batteries for users of materials handling and haulage vehicles are described in booklet issued by *Electric Storage Battery Co.* The catalog consists of an information booklet and five data pages, specifications of Exide Ironclad batteries, accessories and miscellaneous parts. Other items covered include the grid type negative plate, the Mipor separator, rubber jars and covers, vent plugs and connectors, and trays.

(13) LIGHTWEIGHT PIPE: Typical applications of *Naylor Pipe Co.* lockseam spiralweld pipe are shown in bulletin recently issued. Bulletin includes data on fittings, flanges, connections, and pipe specifications from 4 to 30 in. diam. Several fields that use this pipe are construction, dredging, materials handling, mining, oil, paper mill, and power plant.

(14) ELECTRIC HOISTS: No complex devices are needed to mount the *Harnischfeger Corp.* zip-lift for any kind of service. It is an integral unit with built-in lugs which permits direct interchange with either rigid or bolt, hook, or trolley mountings. All gears are full depth, precision cut and shaved for quiet operation and long service lift. Bulletin H26-3 gives condensed information and specifications.

(15) CROSS-FLOW CLASSIFIERS: Principles of surface current classification are discussed in pamphlet C5C-B released by *Denver Equipment Co.* Cross-sectional diagrams show how this classifier gives more efficient classification. Feed distribution gives uniform surface current, conveyor keeps settled sands away from overflow, tank drains down overflow side, and adjustable weir permits flexibility. Specifications of the various models are also included.

(16) TESTING MACHINES: A new 30-page catalog is offered by *Riehle Testing Machines Div., American Machine & Metals, Inc.* The catalog includes illustrations, details of construction, specifications, and dimensions of testing machines up through 400,000 lb capacity. Information is also given on special tools, instruments, and accessories for special tests.

(17) LININGS: Bulletin published by *Atlas Mineral Products Co.* describes the complete line of corrosion proof linings, including sheet lining, solution or dispersion linings, brick sheathings and miscellaneous linings.

(18) SLING CHAINS: Contents of a new brochure obtainable from *Cleveland Chain & Mfg. Co.* includes sling chain safety rules and full data on chain inspection, use and care. Recommended load limits are listed in detail and for various chain sizes and suspension angles. Single and double sling chain specifications are presented in tabular form.

(19) TAMPING ROLLERS: Pamphlet 892 released by *Baker Mfg. Co.* gives complete specifications on single, double, and triple drum models that provide the ultimate in efficient soil compaction. The sheepsfeet are made of forged steel construction for greater strength. The box-type frame has heavily reinforced corners to prevent distortion. The drums are of heavy, arc-welded steel plate pressure-tested. These are just a few of the many useful benefits claimed by the manufacturers.

(20) DUST CONTROL: Detailed selection, operation, and maintenance data is contained in a 50-page book offered by the *Pangborn Corp.* Illustrated with photographs and line drawings, there are three sections: exhaust hoods and piping systems, dust collecting equipment, and exhausters and drives. Application data on the following types of dust collecting equipment is also included: settling chamber, centrifugal collector, baffle type collector, fan type centrifugal separator, wet or washer type collector, electrical precipitator, and cloth type filter.

Mining Engineering — **April**
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New Mining Methods Tested by Menominee Range Iron Ore Producers

by Philip D. Pearson and Warren W. Jamar

IN recent years, there have been many changes in mining operations in the Lake Superior district. To follow these trends on the Menominee Range of Michigan, information has been assembled from all of the iron mining operations in the area. There are 15 operating underground mines in the Iron River-Crystal Falls area of the Menominee Range. Within the past two years, two idle properties were reopened and are now producing, and a third and fourth are being reopened. Also, there are two siliceous openpits operated by independent companies outside this immediate area. Six companies operate the underground mines, employing some 1850 employees. Table I shows pertinent facts about these properties.

During 1949, the largest mine in Iron County shipped 571,287 tons, and one of the newer mines shipped 39,378 tons, with a range total to 3,535,373 tons. Since the Menominee Range was opened in the 1870's, the mines in Iron County have shipped 85,890,922 tons.

From an operator's viewpoint rather than a geologist's, the ore is classified as semi-hard, composed of hematite and limonite. It is not as soft as the ores of the Marquette Range nor is it as hard as the hard ores of the Marquette and Vermillion Ranges. The ore bodies have slate hanging walls and slate footwalls. In most cases the hanging walls and footwalls are soft and high in sulphur. The sulphur comes from pyrite, and these slates will ignite when piled more than 6 to 8 ft high.

Ore is mined on this range by: 1—Sub-level stoping; 2—Shrinkage stoping; 3—Sub-level caving; 4—Block caving; 5—Top slicing. The predominance of these methods is in the order named.

Underground drilling is important in the mining cycle. Some changes made and trends toward future changes fall into four categories: Drill bits, drill steel, drill machines, and compressed air pressures. Several types of bits have been tried and are in use. They include the detachable tungsten carbide insert bit; the intraset steel bit, which is a conventional steel rod with tungsten carbide insert; the one-use bit; and the multiple-use bit.

For many years, detachable multiple-use bits have been standard. In tests conducted recently to improve drilling efficiency, this bit was used as the basis for comparison. Under existing conditions, a multiple-use bit can be resharpened about three times before it is discarded.

A thorough test of 2-in. tungsten carbide threaded bits was conducted under various ground conditions. 1—The drilled footage ranged from 48 to 600 ft per bit; averaging 357 ft per bit. Under these same conditions, a multiple-use bit ranged from 8 to 80 ft per bit. 2—The bit cost was greater for the insert bit in each case. 3—The average drilling speed for the insert bit was 12 in. in 62 sec and for the multiple-use bit was 12 in. in 64 sec.

In a second test, 2¼-in. tungsten carbide bits with the large 1 3/16-in. thread were used in moderately soft ground on a 152-lb drifting drill on a long feed jumbo. 1—The drilled footage ranged from 450 to 5000 ft per bit, averaging 1810 ft per bit. Under these same conditions, a multiple-use bit averaged 64 ft per bit. 2—The bit cost was reduced by the use of the insert bit. 3—No increase in drilling speed was recorded. 4—Minimum footage obtained was caused by thread failure. To improve the thread life, thread size on the rod was increased and the bit was attached to the rod with a pipe wrench. After this, bits failed in equal proportions because of cracked skirts, broken inserts, and gage loss.

Tungsten carbide bits are now used in the operation where this second test was conducted because labor costs were lowered as a result of reducing the number of bits being changed by the miners. At the same operation and under the same conditions as the second test, 1¾-in. insert bits with standard 1-in. threads were used. These bits did not drill much more than 300 ft before thread failure and were then welded to the rods and used until total failure. Sometimes this footage was considerable, sometimes it was not. Chisel-type 2¼-in. insert bits were

PHILIP D. PEARSON, Member AIME, is Superintendent of the Menominee Range Operations of Inland Steel Co., Iron River, Mich., and **WARREN W. JAMAR** is Mechanical Engineer for the M. A. Hanna Co., Iron River, Mich.

Discussion of this paper, TP 3040A, may be sent to the AIME before May 31, 1951. Manuscript, June 7, 1950. Upper Peninsula Section Meeting, Houghton, Mich., May 1950. St. Louis Meeting, February 1951.

This page of Transactions is a continuation from p. 268. The missing pages appeared in Mining Engineering.

found unsatisfactory for two reasons. Thread life was bad, and the bit tended to penetrate too far into the material being drilled and therefore could not be turned by the machine. An overall loss in drilling speed resulted.

Another operator who at present uses insert bits in rock only reported the following: Minimum footage, 236 ft per bit; maximum footage, 905 ft per bit; average, 402 ft per bit. The usual problem of threads was encountered, but thread failure was lessened by close supervision of both the rod and the bit. Go and *No-Go* gages for both rods and bits are furnished to miners and shift bosses, and these men check the rods and bits frequently.

At another mine, drilling in a shaft sinking operation was done with insert bits. Cross and chisel type 1¾ and 1⅝-in. insert bits were used and averaged 190 ft per bit. Thread life was the determining factor, and the chisel-type bits held up longer than cross bits. A multiple-use bit, under the same conditions, drilled about 8 ft per bit. The insert bit cost less than the multiple-use bit cost, and considerable time was saved because it was not necessary to change bits while drilling a cut. All bits were put on the rods in the shop and the threads were inspected. They were rethreaded, if necessary, before strippage occurred. Several operators experimented with attaching the threaded insert bits to the rods with silver solder.

A description of this process, as given by one of these operators, is as follows: The thread of the rod is cleaned in a shot blast and with a wire brush. The bit thread is cleaned as well as possible with a brush. Two holes are drilled in the bit body opposite each other and near the bottom of the thread. The thread end of the rod is heated with a torch to a dull red, and the bit is screwed on with a 24-in. pipe wrench. The skirt of the bit is heated uniformly until the solder flows (about 1200°F). Care must be taken not to overheat the wings of the bit since the inserts are brazed in and will fall out if the weld is overheated. Easy-flow solder in the form of wire is applied in one of the holes until it flows out of the other hole, indicating that any spaces between the threads are filled. During the application of the solder, heat is applied with the

Table I. Data About Operating Mines on the Menominee Range

No.	Depth of Shaft, Ft	1949 Shipments	Number Employed	Mining Methods	Tramming Method	Crushing Method	Stockpiling Method	Skip Loading Method	Distance Between New Levels, Ft	Pumping Capacity, Gpm	Skip Size, Tons
1	1100	527,666	129	Sub-level stope	Tram car and locomotive	Gyratory-underground	Dumptor	Storage pocket and measuring pocket	200	100	4
2	1100	393,029	184	Sub-level stope	Tram car and locomotive	Gyratory-underground	Dumptor	Storage pocket and measuring pocket	200	1400	4
3	2300	300,603	139	Sub-level stope	Tram car and locomotive	Gyratory-headframe	Locomotive and tram car on stockpile	Car — skip	200	500	4
4	2300	268,699	135	Sub-level stope	Tram car and locomotive	Gyratory-headframe	Larry car on stockpile	Car — skip	200	300	4
5	600	39,378	60	Sub-level stope	Tram car and locomotive	Gyratory-headframe	Endless rope and trestle	Car — skip	200	350	4
6	1100	571,287	323	Sub-level stope	Tram car and locomotive	Gyratory-headframe	Endless rope, locomotive and cars and trestle	Trench and measuring pocket	200	260	3
7	1050	273,339	166	Sub-level	Tram car and locomotive	Jaw-underground	Endless rope and dozer dumptor (rock)	Trench and measuring pocket	200	120	3
8	950	191,529	120	Sub-level stope	Tram car and locomotive	Jaw-underground	Endless rope and bulldozer	Rotary dump, storage and measuring pockets	200	130	3
9	1300	New property				Headframe					
10	1300	420,718	97	Sub-level stope	Belt conveyor	Gyratory-headframe	Dumptor	Storage pocket and measuring pocket	250	100	6
11	1650	New property	70	Shrinkage stope	Tram car and locomotive, belt conveyor	Gyratory-headframe	Dumptor	Trench and measuring pocket		100	5
12	1800	346,286	182	Sub-level stope	Tram car and locomotive, belt conveyor	Gyratory-headframe	Larry car and trestle and bulldozer	Rotary dump, car to skip		400	4
13	550	114,386	75	Sub-level stope	Tram car and locomotive		Dumptor	Trench and measuring pocket	200	900	3
14	1250	New property	10	Exploration					150	10	
15	1000	88,453	116	Sub-level and shrinkage stope	Tram car and locomotive	Gyratory-headframe	Locomotive and cars, trestle and bulldozer	Trench and measuring pocket	350	750	5
16		36,607		Open-pit							
17		14,101		Open-pit							
		3,586,081									

Table II. Results of Tests on One-Use Bits

	152-lb Post-Mounted Drifting Drill		127-lb Post-Mounted Drifting Drill		55-lb Hand-Held Drill	
	In. per Bit Use	In. per Min	In. per Bit Use	In. per Min	In. per Bit Use	In. per Min
2⅛-in. Multiple-use bit	30	8.5	39	8.5	60	9.0
2⅛-in. One-use bit	60	8.25	72	8.0	132	9.0

torch to keep the temperature even around the periphery of the skirt. The bit is allowed to cool in air.

The intraset steel bits are being tested. Early results of the tests of one operator were encouraging, averaging approximately 840 ft per rod total life in ground where a multiple-use bit drilled 20 ft per bit. These rods were 1¼-in. rod alloy steel and drilled 2¼ and 2⅛-in. holes. It appears that intraset steel bits may be used profitably, but until tests are completed and more information is available, specific conclusions cannot be set forth.

Three types of one-use bits have been tested at one mine on the Menominee Range. Testing of these bits was complete and results were gratifying. In these tests, three machines were set up in an old stope, and holes were drilled about 6 in. apart, so that for all practical purposes the ground was similar for each bit. Records of air pressure, throttled time, depth of hole, and footage per bit were kept. All told, 400 to 500 bits were used. The results of these tests are shown in Table II. After a production test by using the one-use bit in the actual operation, this operator recently changed over to the one-use bit.

It appears that the tungsten carbide bit on the Menominee Range has no real advantage over the multiple-use bit or the one-use bit. In hard ground, the tungsten carbide bit has an advantage in time and cost; but in the usual Menominee Range ore there is no advantage. Recent tests show that the one-use bit may have an advantage over both the standard multiple-use bit and the tungsten carbide bit. The intraset bit is still being tested and has been adopted for limited uses.

While the various types of drill bits have been well tested, in contrast it appears that the various types of drill rods have not had complete tests. Since bit cost and rod cost per ton mined are related, further tests and improvement on the drill rods can be made.

About 2 or 3 years ago, operators tested alloy steel drill rods. Some changed over completely to the alloy steel rod. At one mine, records of the results with alloy steel as compared to carbon steel were kept. These records showed that, when made up in the mine shops and tested on a block tester and underground, alloy steel rods were about 60 pct as good as carbon steel rods. Alloy steel rods made up at outside sources proved only 30 pct as good as carbon steel rods.

Carbon drill steel, which has been and still is being used at the majority of mines on the Menominee Range, has undergone little change. However, improvements have been in the form of better and closer control. In this regard, one operator obtained the following results: 1-in. hexagon steel, used on a 127-lb drifting drill with 80-lb air pressure (machine running), gave a minimum drilling time of 35 min to a maximum of 250 min, averaging 125 min per rod. Breakage of rods at the minimum time took place at the collar; breakage at the maximum time took place about 6 to 8 in. in front of the collar. Drilling speed averaged about 6 to 8 ipm. Prior to this test, rods had been tested that gave a life of from 10 to about 100 min per rod.

The life of a piece of drill steel after it has had a second shank or a second thread is materially reduced. From this, the question arises as to whether or not it is worthwhile to reshank and rethread.

It appears that little improvement has been made in drill steel, with the exception of better control in heat-treating processes. The introduction of alloy steel has not been successful on this range, and the trend is away from rather than toward it. Since bit cost and rod cost per ton are approximately the same, it would appear advisable to continue to experiment in the hope of finding something better than the carbon steel drill rod.

Important also to the drilling cycle are drilling machines. Almost all manufacturers have improved standard machines or introduced new designs during the past few years. One of the most effective changes was the increase in the length of feed on machines mounted on jumbos for main drifting. These long feeds reduce the time required in the overall drilling cycle. Table III shows the results of a time-study taken for machines with a 2-ft change on an old style, manually-operated jumbo, compared with machines with an 8-ft change mounted on a new style automatically-operated jumbo. The introduction of insert bits helped make possible this change in machines.

A recently opened property adopted as standard in the shrinkage stopes a reverse, air-fed, post-mounted machine. This type is attached to an arm and moved by air pressure and has found application in long hole drilling. It has replaced, to a small extent for specific operations, the hand-held drill on jack legs and the post-mounted drifting drill. Its advantages are: Rod changing is faster, less physical

Table III. Time Study of Drilling Cycle with Two Types of Jumbos

Operation	Old Style Time, Min 2-ft Change — 6-ft Holes	New Style Time, Min 8-ft Change — 8-ft Holes
Setup	20	15
Aligning between holes	65	40
Throttle time	75	80
Tear down	5	5
Total	165	140

Table IV. Drilling Speed vs. Air Pressure

Pressure, Psi	Rate of Penetration in Hard Ground, Ipm	
	3½-in. Power Feed Drifter	2⅝-in. Jack Hammer
60	—	4.3
70	4.8	—
75	5.1	5.5
85	8.0	7.7
90	9.2	9.0
100	11.5	10.3
105	—	10.6 (?)

Fig. 1—Large pieces are hauled to the underground crusher.

work is required, and long holes can be drilled accurately.

The various sized hand-held drills on jack legs are used to advantage in several operations on this range, and drifting drills on posts are used in a few operations.

Drilling speed can be increased by increasing air pressure at the drill machine. This is being done by one large operator by installing the proper sizes of pipes and increasing the air pressure at the compressor. Table IV indicates the increase in drilling speed as the pressure rises. In conjunction with this increased air pressure it is claimed that a reduction in bit and rod cost per foot of drilled holes can be realized. However, no proof of this is available.

Transportation

There are two schools of thought on the Menominee Range as to which system of underground haulage best suits conditions. One is a system of handling large pieces with large locomotives and large tram cars; and the other to reduce the size of material and move it by belt conveyor. Neither system is advocated because there is no conflict. There is a proper place for each.

Where material is harder than normal, operators veer toward the large cars and locomotives. The method of mining at one operation produces large pieces of material. Little effort is made to reduce chunks to a size below 1x2x2 ft, the theory being that no time should be spent in secondary blasting. The material is conveyed to the shaft in 8-ton cars drawn by an 8-ton locomotive and is dumped into a crusher installed at the foot of the shaft. After crushing, the material is stored in a storage pocket, flowing by gravity into measuring pockets and thence into the skip. The loading of the skip is facilitated in that sized material is handled. The skip operator remains on the level to operate loading of skips. Fig. 1 shows large size material entering underground crusher.

Table V. A Haulage System in Operation on Menominee Range

	Conveyors		
	No. 1	No. 2	No. 3
Width of belt, in.	36	36	36
Center to center end pulleys, ft	818	648	635
Capacity, tons per hr	250	250	250
Speed, ft per min	200	200	200
Ac motors, hp	20	20	20
Lift, tail to head pulley, ft	2.1	4.8	5.5

The advantages of this system are: 1—Secondary blasting is minimized. 2—The grizzly, a dangerous operation, is not necessary. 3—Skip loading is easy and the possibility of large chunks being caught in the gates is eliminated, thereby improving the hoisting cycle. 4—The capital required to install a locomotive-tram car haulage system is approximately one third less than the amount required for a belt conveyor installation. 5—It is not necessary to drive the haulage-way in a straight line, as with a system of belt conveyors. 6—It is not necessary to have large concentrations of ore in one area as with a belt conveyor. 7—It is not necessary that 25 ft of ore in vertical distance be tied up because of the grizzly sub used in a belt system.

The size of the material being mined governs the choice of system. The length of haul is also a determining factor in making the choice between tram cars and belt conveyors. In long hauls the capital expenditure is proportionately much greater for belt equipment.

There is a trend on this range toward belt conveyor haulage systems. Fig. 2 shows a typical underground belt installation. In this system, 36-in. wide belts are used in place of the locomotive-tram car system. Table V describes the main haulage system of three belts used at one property. In addition, Table VI shows the amount of material moved to date by these belt conveyors.

In the belt conveyor system, material drops from the stope onto a rail grizzly. Chunks are reduced to a size below 14x14x9 in. Material then drops to a chute 25 ft below, where it is loaded onto a shaker conveyor and conveyed to a 36-in. wide main haulage belt. Fig. 3 shows a shaker conveyor feeding a belt conveyor. The belt conveys the material to the shaft where it drops into a storage pocket, and thence into measuring pockets to be loaded into the skips and hoisted to the surface. The crusher in this system is in the headframe on surface.

The advantages of the belt haulage system are: 1—Horsepower requirements per ton are much less. Table VII verifies this statement. 2—Fewer men

Table VI. Tons of Material Conveyed by Shaker Conveyor and Belt Conveyor at One Property

	Shaker Conveyors, Tons	Belt Conveyors, Tons
1943	59,000	
1944	107,000	
1945	92,000	
1946	90,000	2,500
1947	167,000	120,862
1948	462,524	462,524
1949[a]	387,254	387,254
1950 (Through October)	212,690	212,690
	1,577,468	1,185,830

[a] Total production lower because of six weeks' strike.

Table VII. Power Requirements per Ton of Ore Conveyed

	6-Ton Locomotive and Mine Cars 5-ton Capacity	36-In. Belt Conveyor
Tons per hr	100 max.	250
Tons per kwh	2.4	8.3
Kwh per ton	0.42	0.12
Power cost per 1000 tons ($0.013 per kwh)	5.46	1.56

are required to operate belt conveyors. 3—Belt conveyors are less hazardous than the locomotive-tram car system in tramming. 4—Transportation costs are lower.

Under conditions where the ore is hard, where the ore has a tendency to break in large chunks, where the orebodies are small and scattered, and the haulage road is extremely long, there is no question that the method of large cars, handling large material, is preferable. Under conditions where a large concentration of ore occurs in a comparatively small area, and where the character of the ground is such that there is not a predominance of large chunks and a necessity for secondary blasting, the belt conveyor system is preferable.

Normally, in an underground operation, after hauling material from the working place to the shaft, the next operation is skip loading. On the Menominee Range, there are four methods being employed to load material into skips. These methods are: Dump direct, scraping trench, storage bin-measuring pocket, and storage bin-measuring pocket and crusher.

In the dump direct method, ore is dumped from the car into a skip by a slide. In some cases a separate slide for each skip is used, and in other cases a slide with a hinged gate is used to deflect the material to each skip.

In the scraping trench method, ore is dumped into a trench from tram cars or from belt conveyors. The material is then scraped by an electric hoist into measuring pockets. Each pocket holds one skip, and the material is loaded directly from these pockets into the skips.

In the storage bin-measuring pocket method, the ore is dumped into a storage bin with a capacity of about 200 tons. From this storage bin the ore flows by gravity into skip measuring pockets and then into skips.

In the storage bin-measuring pocket and crusher

Fig. 2—Underground conveyor belt installation typical of those used on the Menominee Range.

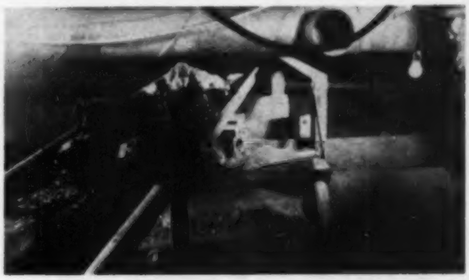

Fig. 3—Shaker conveyor feeding a belt conveyor.

method, ore is dumped into a scraping trench and then scraped into a crusher, dumped directly into a crusher, or dumped onto a feeder which feeds a crusher. From the crusher, ore is fed by gravity into a storage bin and flows from this bin into measuring pockets and then into the skip.

On the Menominee Range all these methods are used. Each has its advantages and disadvantages. If the ore is sticky and wet, the dump direct method or the scraping trench seems most satisfactory. If the ore is not sticky and is blocky, the storage bin-measuring pocket and crusher seems most satisfactory. If the ore is neither blocky nor sticky, the storage bin-measuring pocket seems to have advantages. The only trend is a greater use of the scraping trench, and this comes about where there is water in the ore.

There are several methods of surface stockpiling ore in use on the Menominee Range. These are: 1—Locomotive pulling a tram car supported by a stockpile trestle. 2—Locomotive pulling a tram car on rails supported by the stockpile material. 3—Larry-car supported by a trestle. 4—Endless rope system and wooden trestle. 5—Dumptor. A bulldozer is used to spread the material in several of these operations.

There appears to be a trend in the method of stockpiling ore on the Menominee Range. This trend is evidenced by the fact that since one operator in 1942 began stockpiling ore with a Dumptor, five others have adopted its use, and two others plan to adopt it.

With the Dumptor, ore is hoisted from underground in two 6-ton skips that dump directly into the crusher in the headframe. Crushed ore falls into a pocket large enough to hold one skip. This pocket is emptied through an air cylinder-operated gate into the body of the Dumptor. The Dumptor operator opens the gate when his truck is spotted and closes it when the 6-ton load has been discharged. Each skip makes a separate load for the Dumptor. This operation also could be carried on from a storage pocket. In that case it would not be necessary to tie in the Dumptor operator with the skip operation.

The Dumptor, after being loaded, is driven over a short permanent wooden trestle and directly onto the top of the stockpile. After the width of the pile has been established, each load of ore is dumped over the end of the pile and the pile is built away from the headframe. In building the pile, which in one case is 40 ft high, the operator piles all the ore on the left side of the pile during the daylight hours of work. Fig. 4 shows a Dumptor discharging ore at the edge of a stockpile. During the night shift,

Fig. 4—A dumptor discharges ore at the edge of a stockpile.

the right side of the pile is built. This is done because the left side of the Dumptor is the blind side, and, during night hours, the left edge of the pile can thus be avoided. Working from left to right allows the left wheel on the blind side of the Dumptor to rest on the last material dumped and the distance to the edge of the pile can be estimated where the distance is shortest. The operator stops the Dumptor 3 ft from the edge of the pile and is instructed to use the spare Dumptor at the first signs of any mechanical trouble.

Maintenance work required with this system is relatively low. The top of the pile is occasionally bulldozed to smooth the surface or to remove snow. The roadway, once dozed smooth, freezes solid and requires no further work. The trestle requires new planking about once every 2 years and is completely rebuilt every 5 years because the legs within the stockpile decay. A spare Dumptor usually is used for emergency, and one Dumptor engine is torn down and rebuilt each year. The tires are replaced or repaired, if necessary, during the summer. Conversion from stocking to direct railroad car loading is simple. A portable chute is placed under the storage pocket in place of the Dumptor, and this chute feeds the crushed ore directly into car-loading pockets underneath.

Mining Operation

In underground operations, practices have changed somewhat in recent years. These changes include long hole drilling, underground blasting, main drifting and shaft sinking, and mine supporting.

One operation uses long hole blasting to break material in the stopes. Ore in the area of this mine is softer than the average of the ore on the Range. This fact, along with this operator's ability to control the system, makes possible the use of long hole blasting. Several operators, because of the black slate hazards and because of the secondary blasting in hard ground, did not adopt this system after several comprehensive tests. Long holes are used to remove pillars at other operations, but ring blasting as the predominant method of blasting ore is carried on only at this one property. Results of several tests with ring blasts are shown in Table VIII, and Fig. 5 illustrates long hole drilling using post mounted drifter, as described in Table VIII.

Table IX shows data for long hole drilling using millisecond delay blasting caps, and Fig. 6 illustrates these data.

There appears to be a trend on the Menominee Range toward electric blasting. This fact is shown by the 100 pct use of electric caps by one operator and the partial use of electric caps by practically every operator. In the case of the 100 pct electric blasting, the reason behind its use is the very wet condition in this particular mine. Another operator is experimenting with the thought in mind of going to 100 pct electric blasting because of the recommendation of the safety dept. to make this change.

One item introduced recently in connection with blasting is the millisecond delay. These delays have been used successfully in long hole ring blasting to reduce concussion and improve material size. They also have been used successfully in main level drifting and have shown a powder saving of as much as 20 pct. Some operators complain that, because of the millisecond delays, their drift cuts have not broken completely. However, these delays have decided advantages and gradually will be used in more and more applications.

Another change in blasting practice came about by the introduction of large powder. This powder, 2x16 in., is used by most operators in one or another phase of their operations. One large operator introduced this method of blasting in the stopes, and most of the operators do some of it. The large powder increases the burden on the drill holes, improves

Table VIII. Results of Tests with Ring Blasts

Average burden	10 to 20 ft
Interval between subs 6th to 7th	30 ft

Calculated tons from blast:
11x75x30 ft plus 11x38x26 ft = 35,600 cu ft
Less area previously sliced out [(17x10x12)2 = 4100 cu ft]
35,600 less 4100 = 31,500 cu ft from blast
31,500 divided by 12 = 2625 tons or 525 cars

plus 5°, 20°, 40°, 60°, 90°

Number of holes	14
Total length of holes	358 ft

Powder used—40 pct Special Gelatin, 232 sticks or 696 lbs, plus 500 ft of Primacord

Tons broken per lb of powder—(2625 + 696)	3.77 tons
Tons broken per ft of hole—(2625 + 358)	7.33 tons

Condition of dirt blasted—Mostly big chunks 20 to 30 ft long
Breast of stope—Blast broke to holes

*Time required in drilling holes—Eight shifts, two men per shift

Average amount of hole drilled per shift	45 ft

Drilling Equipment—Post-mounted, water liner for eight holes
Jackhammer and leg for four holes
Stoper for two holes

Large couplings used—None broken
No. 2—Drilled 71 ft when rod broke and spoiled thread
No. 6—Drilled 24 ft then lost in hole because of broken rod
No. 4—Drilled 232 ft and still good

New bits drilled 30 to 60 ft before dulling
Used and reground bits drilled 6 to 30 ft

Time required for loading holes	3 hr, 20 min

* (Includes all delays and time for other pertinent work)

Table IX. Long Hole Drilling Using Millisecond Delay Caps

Theoretical tons from blast—

$$\frac{(9.5\text{x}75\text{x}30\text{ ft} - 9.5\text{x}25\text{x}8\text{ ft})}{12\text{ cu ft per ton}} = 1624\text{ tons or }325\text{ cars}$$

Number of holes	10
Length of holes	257 ft
Powder used (45 pct Gelex No. 2)	157 sticks (314 lb)
Tons broken per lb of powder	5.17 tons
Tons broken per ft of hole	6.32 tons

Conditions of dirt after blasting—Chunks 2 to 8 ft, hard to break on grizzly

Breast of stope after blast—Broke to holes. Bottom right hole apparently didn't break. By measurement, all three ring blasts left 4 or 5 ft against east pillar.

Difficulty in drilling this round of hole encountered because of breaking drill steel at threaded ends.

Electric blasting with Millisecond Delay—Two caps in each primer prevents cutoffs.

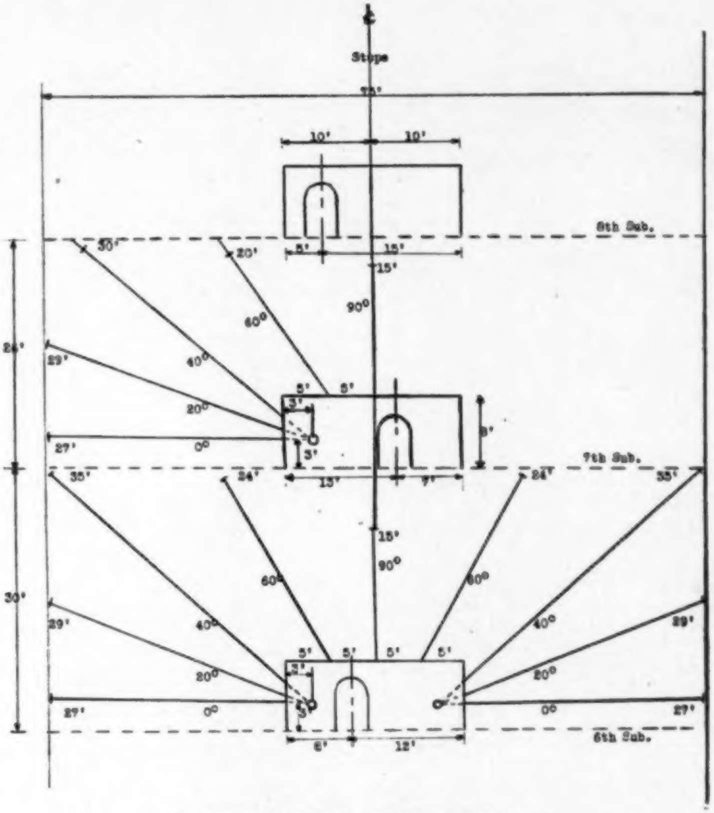

Fig. 5—Long hole drilling using post mounted drifter.

breakage, and increases the tons of material broken per pound of powder used.

Some recent methods in main drifting, which are different than in past years, are: 1—Use of the long feed automatic jumbos, 2—tungsten carbide bits, 3—large powder, 4—millisecond delays, 5—conveyor belts, and 6—improved ventilation. The shaft sinking operations have been improved by mechanical loading. Most sinking on this range in recent years has been between levels for a distance of 200 ft or less.

There are several methods of mine support employed on the Menominee Range. Included are untreated timber sets, treated timber sets, steel sets, and, in recent months on an experimental scale, roof bolts. One large operator installed a timber treating plant and treats all the underground timber. Figures prove savings over a long period of time.

Under dry conditions, steel sets are sometimes used. These sets are painted with acid-resisting paint. They have a lower installation cost than timber sets, but cost three times as much as timber. Experiments are being conducted to replace with steel hat-sections the wooden poles used over the top of these steel sets.

One operator has used roof bolts in a drift and to support ground that is not particularly heavy in other areas. Roof bolting doubtlessly will have limited use, but more tests will be necessary.

Water problems on this range are surface water and underground acid water. By the use of churn drill test holes, one operator determined that an underground lake existed over the working places of his mine. As ordinary ground acts as the shore line and bottom of a surface lake, so a ledge acts as a shore line and bottom of an underground lake. These test holes that gave the water elevations of this lake also indicated the elevation of the ledge material. From this information, a ledge contour map was made and the shore line of the lake was interpreted. It was shown to be a subterranean ravine running northwest and southeast over the orebodies and working places of the mine.

The amount of water that will enter a mine depends on two things, the ease with which it may seep through the ground and the head of water that causes this seepage. Nothing can be done to change the character of the ground, but the head of water over this ground can be controlled by the use of deep well pumps.

There were two methods employed for locating deep well pumps at this mine. The first was to place a number of deep wells to ledge across the southeast end and another group across the northwest end of the ravine. It was expected that by this system, the inflow into the area between the groups of pumps would be stopped and that the water elevation

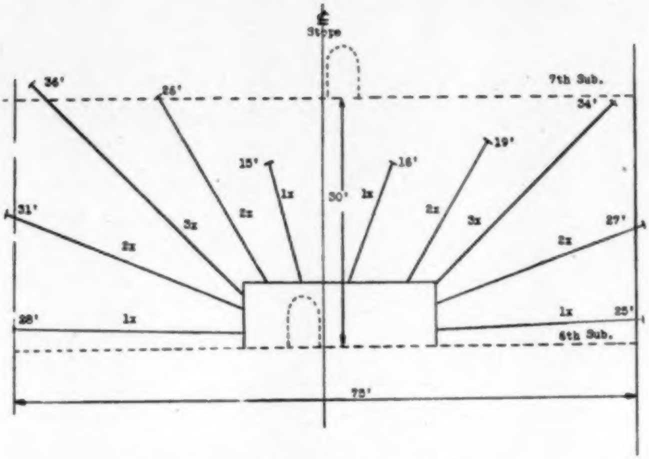

Fig. 6—Long hole drilling using millisecond delay caps.

eventually would be lowered. This method has been successful.

The second method is based on the fact that water will seep from a higher to a lower elevation in the iron formation on this range. On this theory, deep wells were sunk to the ledge as near to the iron formation as possible and directly over the iron formation in most cases. This technique reduced seepage into the working places.

Some of the results of the deep well pumping to date are: 1—All places where shafts enter ledge are presently above water except one, which is 18 ft below water. 2—Stope filling raises can now be made to surface without a water seal at the ledge since they will be above water. Likewise a great deal more dirt to be used for stope filling is now available because it is above water. 3—The depth of water in this underground ravine has been reduced about 60 ft and therefore the head has been reduced. 4—Even though the total water pumped by both mine pumps and deep well pumps is greater than that which would be pumped with mine pumps alone, the horsepower requirements are less since the head requirements with the deep well pumps are about eight times less. 5—Deep well pumps seem to eliminate or reduce the peak pumping normally required because of spring run off.

From experience with deep wells on this range, it appears they are effective in controlling surface water above and in the area of ore bodies. There are two important considerations regarding the location of pumps: The contours of areas to be pumped, and the permeability of ground at pump locations.

Deep well pumping has been successful on the Menominee Range, and operators on other ranges have employed this same system to control the surface water above orebodies.

Quite a number of mines on the Menominee Range have acid in the underground water. One operator has had this problem to contend with for some time. The water contains sulphuric acid. The strength of the acid in this water varies from very weak on some levels to very strong on other levels. The life of a 4-in. iron pipe in some of the stronger water was less than 10 days. This operator attempted to mix the strong acid water with the weak acid water before pumping. However, at one main pumphouse the water is 0.8 pct sulphuric acid. Lime was added to the water, but this was not successful because of the quantity required.

This operator found it satisfactory to install pumps and piping of such material that the acid has little effect. Plunger pumps have been protected by spraying stainless steel on the poles, cement lining the pots, and using stainless valves and throat bushings. Porcelain poles have been used satisfactorily. However, sometimes chipping has been excessive and, because the cost of these poles is high, they are not used to any great extent. Centrifugal pumps have been protected by using stainless steel for casings and internal parts, and by using acid resistant bronze. The acid resistant bronze does not, however, hold up as well as the stainless steel.

Pump columns and suctions have been protected by two methods: 1—*Concrete lined pipe*—This method is satisfactory. However, it has its disadvantages, such as a reduction of about ¾ in. in pipe size plus the necessity of chipping to keep the pipe clean after installation. 2—*Rubber lined pipe*—This is satisfactory but initial cost is high. It seems as though no chipping of the line for the purpose of cleaning is necessary after installation.

Valves of acid-resistant bronze, stainless steel, and cement lining have been used. The stainless steel has proved best but is most expensive. Rubber lined stainless steel trim valves can be obtained, but none have been tried. However, they should be satisfactory. A new type plastic pipe has been tried for low pressures and for suction lines. This will likely prove satisfactory.

Automatic pumping at one operation would be desirable because the daily inflow of water to the mine can be stored and pumped to surface from one level, the pumping being done between shifts to avoid affecting the electrical peak. This former arrangement necessitated sending a pumpman underground between shifts. The system as installed consists of three parts, the priming circuit, the starting circuit, and the alarm circuit. It is diagrammed in Fig. 7.

The priming circuit consists of a priming tank,

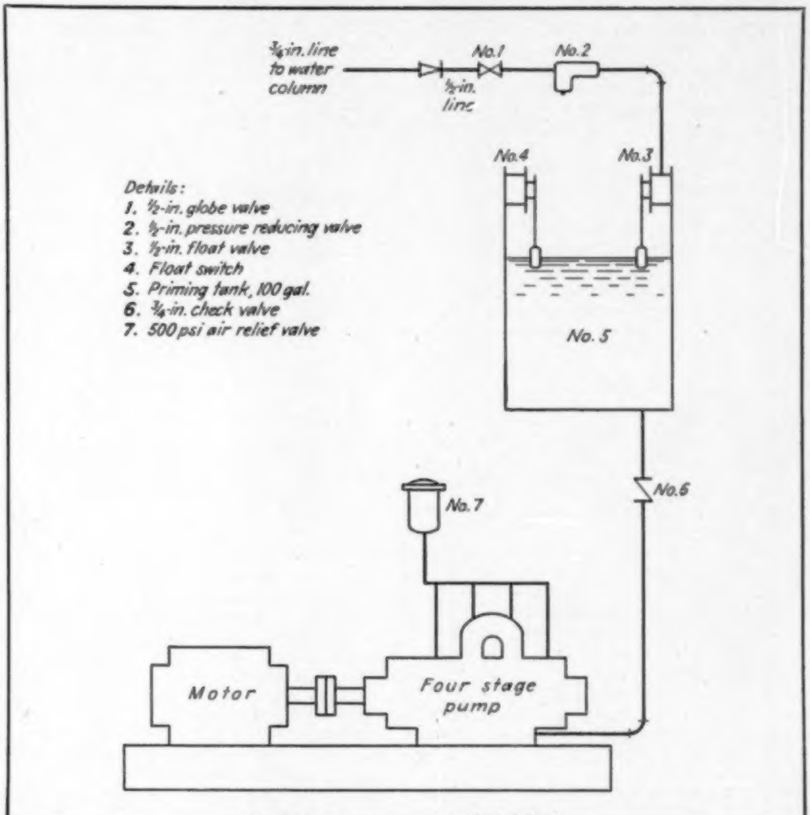

Fig. 7—Pumping arrangement at 1000-ft level.

No. 5 in Fig. 7, connected to a constant source of water through a flow-control valve, No. 3. This valve maintains the tank water level. The tank is mounted above the pump, and water flows to the pump by gravity to keep it primed. The air is bled from the pump casing by an air vent trap, No. 7 in Fig. 7.

The starting circuit consists of a magnetic full voltage starter for the 250-hp motor with switches in series to start and stop the motor. The switches are: A time clock to allow only off-peak operation, a float switch to assure sufficient water in the sump, a timing relay and pressure switch to make sure the pump builds up pressure in a designated time, and a float switch (No. 4 in Fig. 7) in the priming tank to check on the water level in it.

The alarm circuit, installed in the engine house where there is constant attendance, consists of four lights and an alarm. A green light indicates low water level in the sump, an amber light indicates sufficient water for pumping but *on-peak-time*, a white light indicates the pump is running satisfactorily, and a red light indicates that the time clock and float call for pump operation but something is wrong. Along with the red light, a horn sounds. This can be turned off manually.

Winter ventilation, stope filling, sulphur fires, and safety and management are also subjects of interest and items where developments have taken place. Mine ventilation has become more important in the past few years. This probably because mines have become larger, and because more thought has been given to the importance of fresh air at the working place. Most plants on this range steam heat the air for underground, a common method. There is, however, a trend to utilize warm air furnaces to heat the air for underground.

In one system of this nature, a fan forces air through a warm air furnace where the air is heated and then is sent underground. Bonnet temperature of the furnace controls the stoker or oil burner. The amount of air passed through the furnace is governed by thermostatic controlled dampers that permit a portion or all of the air to go through the furnace, or allow it to bypass the furnace. Thus, a constant temperature of about 36°F is maintained. This unit has been used where up to 10,000 cfm of air is required.

At another installation, where a maximum capacity of 80,000 cfm is used, a warm air furnace and two fans are used. One fan of 50,000 cfm takes in fresh air and discharges this air through the warm air furnace into a mixing chamber where the fresh air from outside also can be drawn in through backdraft louvers. From this chamber, a large 80,000-cfm fan, under 5-in. static pressure with fluid

coupling to give variable speed, draws in the fresh and heated air and discharges it down a shaft into the mine. The small 50,000-cfm fan operates continuously when the furnace is in use and is shut down when the furnace is not in use. This fan merely provides a positive pressure on the furnace so that any gases from the furnace do not enter the fresh air.

The speed of the large fan is controlled by outside air temperature through the use of the fluid coupling. This control is predetermined and set so that as the temperature drops, the capacity of the large fan is reduced and thus will not exceed the capacity of the furnace.

The stoker of the furnace is controlled by discharged air temperature entering the shaft. This gives final close control of the air temperature going down the shaft and is set about 36°F.

The principal advantage of warm air heating is that there are no steam or water lines to freeze. It is also believed that the warm air system is more efficient, since lower stack temperatures are maintained and heat loss to the boiler room is reduced.

Sulphur black slate exists in both the hanging and foot walls of mines on this range. This black slate will spontaneously ignite when it is piled more than 6 to 8 ft deep. Sometimes it is impossible to keep the black slate from coming into an open stope. When this happens, a fire is likely to start, and the only successful way known to put it out is to cut off the air to the stope. Sometimes bulkheads will accomplish this. If bulkheads cannot be used, then the fire must be smothered with dirt. This is accomplished by stope filling.

Stope filling has three main purposes. It reduces the possibility of material sloughing off an old stope and thereby causing a fire. It extinguishes a burning fire. It makes possible the recovery of pillars left in the mining operations.

This stope filling is accomplished through a system of raises and churn drill holes, 30 in. diam. Surface material is allowed to fill one stope, then the floor pillar is blasted out, and the material is allowed to drop into the stope below. Sometimes these stopes do not exist one above the other, and this material is conveyed by belt from one raise to another. After this surface material has remained in a stope for a few years, it is believed safe to return and rob the pillars. To do this a thin wall of ore is left next to the stope fill, so that this fill will not run into the pillar being mined. Several operators in the district are working toward this end.

Companies on the Menominee Range are safety conscious, as is indicated by their records. Two companies have a 100 pct goggle rule. There appears to be a trend toward more training of shift bosses and mine supervisors. This trend seems necessary because the shift boss and the captain must be prepared to make decisions on the spot before they have had an opportunity to consult with supervisors. Also, a good job by these men can prevent grievances and add to the harmonious operation of these mines.

Conclusion

A method to set forth the summation of the information in this report might be to describe an ideal property, using the methods that the operators feel are best suited to the conditions on this range, keeping in mind the trends and the progress made during recent years. An ideal mine might be as follows:

I. **Drilling Methods:**
   A. One-use bits in soft ground.
   B. Tungsten carbide bits in hard ground.
   C. Carbon steel rods prepared under carefully controlled temperatures in a well equipped shop.
   D. Light hand-held machines on jack legs in soft ground. Pneumatic-feed machines on pneumatic posts in hard ground and for long holes.
   E. Air pressures 100 to 110 psi.

II. **Transportation:**
   A. Large tram cars and locomotives and heavy rails to haul hard massive chunks with the crusher underground. Conveyor belts for large concentrations of ore with average chunk problems. Crusher to be on surface.
   B. Dumptor or similar device for stockpiling.

III. **Operations:**
   A. Long hole ring blasting in soft ground and in pillars. Large holes and large powder, or small holes drilled with insert bits, in hard ground.
   B. Electric blasting millisecond delays.
   C. Tungsten carbide bits on long feed machines on pneumatic jumbo for drifting.
   D. Shaft sinking with tungsten carbide bits, and clam shell muckers.
   E. Mine supports of treated timber or steel sets.

IV. **Water problems:**
   A. Deep wells to control surface water.
   B. Acid-resisting pumps and pipes for underground water.
   C. Automatic pumping.

V. **General:**
   A. Heated ventilation with hot air furnace.
   B. Stope filling to control sulphur fires and recover pillars.
   C. Clutch drum hoist.
   D. Electric eye control for skips.
   E. Low headframe with conveyor belts to carry material to crusher, storage pocket, or stockpile.
   F. Consolidation of shops, dry and garages, in one building, in addition to an engine house and office building. Enclosed passageways between buildings and the collar of the shaft.

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Grinding Mills as Conditioners in Sulphide Flotation

by C. G. McLachlan

Laboratory flotation tests carried out on massive sulphide ores may not be reproduced in plant practice, and when this occurs the discrepancy can be the result of differences between laboratory and plant grinding. Results of parallel flotation tests are given to support this contention, and data show how tailing losses are affected in corresponding size zones.

ONE phase of the treatment in sulphide flotation, covered generally in a review of pulp pretreatment by S. A. Falconer,[1] is the matter of grinding mills as conditioners, a subject on which further study could be advantageous. Flotation with few exceptions is preceded by grinding, and the grinding and flotation capacity required for the treatment of an ore is based generally on laboratory or pilot mill tests. The results of such tests, it then is assumed, will be duplicated in practice, and a flowsheet is prepared on that basis.

This assumption may be too broad, because in several instances laboratory flotation tests made on massive sulphide copper ores could not be duplicated in plant operation without the introduction of an aeration step, either in closed circuit with the grindinging mills, or between grinding and flotation.[2, 3]

The differences between laboratory and plant grinding practice are considerable, and may be summarized as follows:

1—In the laboratory a relatively fine charge is ground in a batch mill. In the plant, the feed, usually considerably coarser than the ore tested in the laboratory, enters the grinding mill continuously and more often than not, oversize material in the mill discharge is retained in the grinding circuit by a classifier until the required degree of reduction has been effected.

2—The rate of grinding in the laboratory is slower than in plant practice.

3—The percentage of volume occupied by the pulp in a laboratory mill rarely approaches that of a continuous overflow type mill. This does not apply if the comparison is made with grate type mills, but in that case an even wider discrepancy between the relative rates of laboratory and mill grinding almost invariably exists.

The present trend in grinding is toward larger mills to reduce the number of operating units. This accentuates the foregoing differences. It is believed that the trend toward larger mills is sound, but that when large mills are used, metallurgists should check their flotation circuits carefully to determine whether laboratory tests are being reproduced in

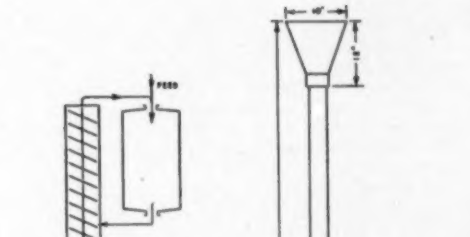

Fig. 1 (Left)—Grinding flowsheet used for mill tests. (Right)—Laborator aerator.

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Table I. Tests with Lime

Treatment Before Flotation	Product	Plant Grinding: Cu Assay, Pct	Plant Grinding: Cu Recovery, Pct	Laboratory Grinding: Cu Assay, Pct	Laboratory Grinding: Cu Recovery, Pct
None	Heads Conc. Tail.	1.43 6.24 1.13	25.8	1.39 6.67 0.37	77.6
20-min agitation laboratory flotation cell, air inlet closed	Heads Conc. Tail.	1.42 6.34 1.10	27.2	1.39 6.32 0.55	66.2
20-min agitation laboratory flotation cell, air inlet open	Heads Conc. Tail.	1.42 10.64 0.70	54.3	1.40 12.98 0.22	85.8
20-min laboratory aerator	Heads Conc. Tail.	1.42 10.31 0.77	49.6	1.39 11.24 0.14	91.1

Table II. Tests with Soda Ash and Cyanide

Treatment Before Flotation	Product	Plant Grinding: Cu Assay, Pct	Plant Grinding: Cu Recovery, Pct	Laboratory Grinding: Cu Assay, Pct	Laboratory Grinding: Cu Recovery, Pct
None	Heads Conc. Tail.	2.67 7.93 1.07	47.4	2.60 9.44 1.13	64.2
20-min agitation laboratory flotation cell, air inlet closed	Heads Conc. Tail.	2.77 9.10 0.96	73.1	2.61 6.87 0.53	86.4
20-min agitation laboratory flotation cell, air inlet open	Heads Conc. Tail.	Corresponding test not run		2.60 10.56 0.57	82.5
20-min laboratory aerator	Heads Conc. Tail.	2.77 14.56 0.64	80.4	2.61 14.28 0.25	92.0

plant practice. This usually can be done by taking a sample of classifier overflow, or flotation feed, and comparing the flotation results obtained in the laboratory with those of a duplicate test in which a sample of the mill feed is ground in the laboratory to the same degree of fineness and subjected to identical flotation treatment.

Table III. Linking Tests Using Laboratory Grinding and 20-Min Aeration

Test	Product	Tests With Lime: Cu Assay, Pct	Tests With Lime: Cu Recovery, Pct	Tests With Soda Ash: Cu Assay, Pct	Tests With Soda Ash: Cu Recovery, Pct
Linking test for lime series	Heads Conc. Tail.	1.39 11.24 0.14	91.1	1.40 9.94 0.13	91.9
Linking test for soda ash series	Heads Conc. Tail.	2.62 12.35 0.33	89.8	2.61 14.28 0.25	92.0

In those cases where satisfactory agreement between laboratory and mill flotation results does not exist because of grinding circuit differences, it has been found that they most frequently occur when the following types of ore are being treated: 1—Massive sulphide ores, particularly those containing pyrrhotite, 2—ores containing reducing agents such as "ous" salts, and 3—ores forming colloidal slimes when ground. This list is not intended to be complete, but it should be indicative.

The term duplication of results means not only duplication of metallurgical performance and the use of equivalent quantities of flotation reagents, but also duplication of the actual flotation periods required for treating respective pulps.

An example of the type of discrepancy referred to is shown by the results of the following series of parallel flotation tests which were carried out on laboratory, and mill ground products, with ore currently treated by the Noranda concentrator.

The detailed procedure used for these tests and other related data will be found in the appendix. A flowsheet of the mill grinding circuit employed and the laboratory aerator are shown in Fig. 1.

Table IV. Tabulation of Assays of Sized Tailings Products

Where Ground	Treatment Before Flotation	Alkali	Micron Zones: +56	−56 +40	−40 +28	−28 +20	−20 +14	−14 +10	−10	Cum.
Plant	None	Lime	1.12	1.25	0.94	0.75	0.79	1.05	1.51	1.13
Laboratory			0.40	0.15	0.11	0.11	0.13	0.22	0.84	0.37
Plant	20-min agitation laboratory flotation cell, air inlet closed	Lime	1.12	1.25	0.84	0.64	0.66	0.89	1.46	1.10
Laboratory			0.65	0.24	0.10	0.15	0.20	0.48	1.25	0.55
Plant	20-min agitation laboratory flotation cell, air inlet open	Lime	0.90	0.38	0.17	0.12	0.14	0.26	0.98	0.70
Laboratory			0.29	0.09	0.07	0.07	0.07	0.11	0.42	0.22
Plant	20-min laboratory aerator	Lime	0.98	0.40	0.24	0.18	0.21	0.37	1.20	0.77
Laboratory			0.16	0.07	0.05	0.05	0.06	0.10	0.36	0.14
Laboratory link test	20-min laboratory aerator	Soda ash	0.12	0.06	0.07	0.07	0.09	0.10	0.38	0.13
Plant	None	Soda ash	2.18	1.50	0.60	0.39	0.33	0.48	2.15	1.67
Laboratory			1.27	0.51	0.37	0.36	0.59	1.33	2.31	1.13
Plant	20-min agitation laboratory flotation cell, air inlet closed	Soda ash	1.25	0.25	0.16	0.16	0.18	0.49	2.08	0.96
Laboratory			0.56	0.12	0.11	0.12	0.17	0.46	1.47	0.53
Laboratory	Air inlet open	Soda ash	0.66	0.11	0.09	0.11	0.18	0.45	1.20	0.57
Plant	20-min laboratory aerator	Soda ash	0.96	0.20	0.15	0.11	0.15	0.21	1.03	0.64
Laboratory			0.26	0.11	0.10	0.09	0.13	0.27	0.79	0.25
Laboratory link test	20-min laboratory aerator	Lime	0.41	0.13	0.10	0.10	0.10	0.15	0.45	0.33

Table V. Flotation Tailings Infrasizing Analyses, Lime Series (Data for Table IV)

Type of Grinding	Treatment Before Flotation	Alkali	Product, Pct	Micron Zones +56µ	56-40	40-28	28-20	20-14	14-10	−10	Total	Tailing (calc.)
Plant	None	Lime	Weight	52.2	10.4	8.7	6.0	4.7	4.9	13.1	100.0	
			Assay Cu	1.13	1.25	0.94	0.75	0.79	1.05	1.51		1.13
			Distribution Cu	52.0	11.5	7.2	4.0	3.3	4.6	17.4	100.0	
Laboratory	None	Lime	Weight	49.8	12.5	10.4	7.0	5.2	3.9	11.2	100.0	
			Assay Cu	0.46	0.15	0.11	0.11	0.13	0.22	0.84		0.37
			Distribution Cu	60.9	5.0	3.1	2.0	1.8	2.3	24.9	100.0	
Plant	20-min agitation laboratory flotation cell, air inlet closed	Lime	Weight	49.2	10.3	9.2	6.4	5.0	4.2	15.7	100.0	
			Assay Cu	1.12	1.25	0.84	0.64	0.66	0.80	1.46		1.10
			Distribution Cu	50.2	11.8	7.0	3.7	3.0	3.4	20.9	100.0	
Laboratory	20-min agitation laboratory flotation cell, air inlet closed	Lime	Weight	52.2	11.6	9.8	6.7	4.8	4.1	10.8	100.0	
			Assay Cu	0.65	0.24	0.10	0.15	0.20	0.48	1.25		0.55
			Distribution Cu	61.8	5.1	1.8	1.8	1.7	3.1	24.7	100.0	
Plant	20-min agitation laboratory flotation cell, air inlet open	Lime	Weight	47.8	11.2	9.4	6.8	5.2	4.8	14.8	100.0	
			Assay Cu	0.98	0.38	0.17	0.12	0.14	0.26	0.98		0.70
			Distribution Cu	69.0	5.7	2.1	1.1	1.0	1.7	19.4	100.0	
Laboratory	20-min agitation laboratory flotation cell, air inlet open	Lime	Weight	52.1	12.3	10.2	6.7	4.8	4.1	9.8	100.0	
			Assay Cu	0.29	0.09	0.07	0.07	0.07	0.11	0.42		0.22
			Distribution Cu	67.8	5.0	3.2	2.1	1.5	2.0	18.4	100.0	
Plant	20-min laboratory aerator	Lime	Weight	52.3	10.3	8.8	6.2	5.0	4.3	13.1	100.0	
			Assay Cu	0.98	0.40	0.24	0.18	0.21	0.37	1.20		0.77
			Distribution Cu	66.6	5.3	2.7	1.5	1.4	2.1	20.4	100.0	
Laboratory	20-min laboratory aerator	Lime	Weight	50.3	12.5	10.4	7.0	5.1	3.8	10.9	100.0	
			Assay Cu	0.16	0.07	0.05	0.05	0.06	0.10	0.36		0.14
			Distribution Cu	55.9	6.1	3.6	2.4	2.1	2.6	27.3	100.0	
Laboratory link test	20-min laboratory aerator	Soda ash	Weight	47.9	12.4	10.6	7.3	5.6	5.1	11.1	100.0	
			Assay Cu	0.12	0.08	0.07	0.07	0.09	0.10	0.38		0.13
			Distribution Cu	43.5	7.5	5.6	3.9	3.8	3.8	31.9	100.0	

Table I shows the results obtained in a series of tests in which lime was added to the grinding mill to provide protective alkalinity.

Examination of the figures given in this table shows that a very considerable difference exists between the flotation results obtained on the mill-ground and the laboratory-ground pulps; also, that these variations are influenced by the method used for treating the pulp after grinding and before flotation.

At Noranda these variations can be reduced by using soda ash and cyanide in place of lime. Confirmation of this statement will be found by comparing the recovery figures given in Table II with those of Table I.

In spite of the reduction in the discrepancy shown by the results given in Table II, a serious difference still exists in favor of the laboratory. In plant practice it has been found that if a soda ash circuit is used, satisfactory correlation between the mill and the best laboratory tests can be obtained by operating aerators in closed circuit with the grinding mill and bringing back a fair circulating load of middling, which is reaerated before being refloated. Xanthate consumption in the mill is, however, somewhat higher than indicated by the laboratory tests, and certain auxiliary circuits, which are employed to recover finely interlocked gold, also recover some copper. Actually, plant performance for the period within which the tests listed in Table II were car-

Table VI. Flotation Tailings Infrasizing Analyses, Soda Ash Series (Data for Table IV)

Type of Grinding	Treatment Before Flotation	Alkali	Product, Pct	Micron Zones +56µ	56-40	40-28	28-20	20-14	14-10	−10	Total	Tailing (calc.)
Plant	None	Soda ash	Weight	46.9	10.8	9.8	6.6	5.2	4.7	15.9	100.0	
			Assay Cu	2.18	1.59	0.69	0.39	0.33	0.48	2.15		1.67
			Distribution Cu	61.3	10.3	4.0	1.5	1.1	1.3	20.5	100.0	
Laboratory	None	Soda ash	Weight	65.7	8.3	7.2	5.0	4.4	3.5	5.9	100.0	
			Assay Cu	1.27	0.51	0.37	0.36	0.59	1.33	2.31		1.13
			Distribution Cu	73.8	3.7	2.4	1.6	2.3	4.1	12.1	100.0	
Plant	20-min agitation laboratory flotation cell, air inlet closed	Soda ash	Weight	41.7	11.0	10.2	7.5	6.3	7.2	16.1	100.0	
			Assay Cu	1.25	0.25	0.16	0.16	0.18	0.49	2.08		0.96
			Distribution Cu	54.3	2.9	1.7	1.2	1.2	3.7	35.0	100.0	
Laboratory	20-min agitation laboratory flotation cell, air inlet closed	Soda ash	Weight	65.8	7.9	6.8	4.8	3.9	3.7	7.1	100.0	
			Assay Cu	0.58	0.12	0.11	0.12	0.17	0.46	1.47		0.53
			Distribution Cu	71.7	1.8	1.4	1.1	1.2	3.2	19.6	100.0	
Plant	20-min agitation laboratory flotation cell, air inlet open	Soda ash	Weight	Corresponding test not run								
			Assay Cu									
			Distribution Cu									
Laboratory	20-min agitation laboratory flotation cell, air inlet open	Soda ash	Weight	65.0	7.8	7.1	5.4	4.1	2.5	8.1	100.0	
			Assay Cu	0.66	0.11	0.09	0.11	0.18	0.45	1.20		0.57
			Distribution Cu	75.8	1.5	1.1	1.1	1.3	2.0	17.2	100.0	
Plant	20-min laboratory aeration	Soda ash	Weight	41.0	11.5	10.8	7.4	6.2	6.3	16.8	100.0	
			Assay Cu	0.96	0.29	0.15	0.11	0.15	0.21	1.03		0.84
			Distribution Cu	61.9	3.6	2.5	1.3	1.5	2.1	27.1	100.0	
Laboratory	20-min laboratory aeration	Soda ash	Weight	63.3	8.6	7.7	5.6	4.9	4.4	5.5	100.0	
			Assay Cu	0.26	0.11	0.10	0.09	0.13	0.27	0.79		0.25
			Distribution Cu	66.2	3.6	3.1	2.0	2.6	4.8	17.5	100.0	
Laboratory (link test)	20-min laboratory aeration	Lime	Weight	64.5	8.5	7.3	4.8	3.7	2.9	8.3	100.0	
			Assay Cu	0.41	0.13	0.10	0.10	0.10	0.15	0.45		0.33
			Distribution Cu	79.5	3.3	2.2	1.4	1.1	1.3	11.2	100.0	

ried out, showed a copper recovery of 95.9 pct and a ratio of concentration of 6.5:1. Repeated attempts have been made in the mill to duplicate the best laboratory results with lime but these have always failed.

The copper content of the two lots of ore tested in Tables I and II varied considerably because the two series were not run on the same day. To provide for this eventuality and to enable a better comparison between each series, two laboratory linking tests were run, one with soda ash and cyanide plus aeration on the sample of ore used for the lime tests, and the other with lime plus aeration on the sample used for the soda ash tests. Results for both tests are given in Table III, where for purposes of comparison, those for the corresponding opposite tests already recorded in Table I and II are shown.

The tailings for the tests covered by Tables I, II, and III were infrasized,[4] so that the copper assays and weights in the different size zones could be determined and compared. These data will be found tabulated in detail in Tables V and VI, but the assays of the sized products have been summarized for convenience and are listed in Table IV.

In comparing these sizing data, consideration must be given to the fact that the tailings for the soda ash series were made on ore averaging 2.65 pct copper, while the ore for the lime series contained only 1.40 pct copper.

It should be noted that if the plant-ground and laboratory-ground products are considered as comprising two separate groups, the tests in which the lowest tailings were made in each group were also those in which relatively high grade concentrates were produced; *also, that the lower the overall tailing, the flatter the assay curve.* These points are of interest because Noranda ore is relatively fine grained, and yet the figures show that the conditions established prior to flotation are much more important in determining the grade of concentrate and the copper recovery than any degree of interlocking which existed within the grinding limits used.

Acknowledgment

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Appendix

Mineralogical Content of the Ore Tested

	Lime Series, Pct	Soda Ash Series, Pct
Chalcopyrite	4.1	7.8
Pyrite	23.4	24.0
Pyrrhotite	58.2	55.7
Insol	10.1	11.2

Specific Gravity of Ore, 4.1

Screen Analysis of Ball Mill Feed

Mesh	Wt, Pct	Mesh	Wt, Pct
+0.525 in.	8.7	—20 + 28	3.1
—0.525 + 0.371	12.3	—28 + 35	2.7
—0.371 + 3	12.4	—35 + 48	3.3
—3 + 4	11.7	—48 + 65	3.2
—4 + 6	8.1	—65 + 100	3.4
—6 + 8	7.2	—100 + 150	2.9
—8 + 10	5.3	—150 + 200	1.8
—10 + 14	4.4	—200	5.8
—14 + 20	3.7	Total	100.0

Plant Grinding Circuit

Mill Operated In Closed Circuit With Akins Classifier

Tonnage:	12 tons per hr
Ball size:	maximum diameter 4 in.
Pulp density:	mill discharge 77 to 78 pct solids classifier overflow 45 to 46 pct solids.

Laboratory Grinding Data

Rod Mill:	8x15 in. (inside measurements)	Size of feed:	ore crushed to —4-mesh
Speed:	72 rpm	Pulp charge:	2000 g ore, 570 cc water
Rod charge:	25 rods, 1 to ⅝ in. diam total weight, 50 lb	Grinding period:	lime series 13 min soda ash series 8 min

Screen Analyses

	Akins Classifier Overflow		Laboratory Mill Discharge	
	Lime Series	Soda Ash Series	Lime Series	Soda Ash Series
Mesh	Wt, Pct	Wt, Pct	Wt, Pct	Wt, Pct
+65	3.0	3.6	0.1	3.2
—65+100	10.8	7.9	2.3	15.8
—100+150	14.9	13.6	13.9	21.4
—150+200	11.1	12.3	16.6	11.7
—200	60.2	62.6	67.1	47.9

Test Procedures for Laboratory Flotation of Mill-Ground Ore

1—Reagents added to head of mill:
  a—Soda ash series: soda ash, 4.0 lb per ton
    sodium cyanide, 0.06 lb per ton
  b—Lime series: calcium hydrate, 5.0 lb per ton
    (65 pct available CaO)

2—a—Tests with no treatment before flotation: Collector (0.1 lb per ton potassium amyl xanthate) added, and sample transferred to 2000-g Denver laboratory flotation machine. Pine oil (3 drops) added and pulp diluted to 25 pct solids. Floated for 5 min.
  b—Tests using agitation with and without air before flotation: Collector added and sample transferred to Denver flotation machine. Pulp agitated 20 min at 40 pct solids, pine oil added and pulp diluted to 25 pct solids. Floated for 5 min.
  Note: When agitating without air, the speed of the flotation machine was reduced to keep air from being beaten into the pulp.
  c—Tests with aeration before flotation: Collector added and pulp transferred to laboratory aerator. Pulp aerated 20 min at 40 pct solids. Aerated pulp transferred to Denver flotation machine, pine oil added and pulp diluted to 25 pct solids. Floated for 5 min.

Procedure for Laboratory-Ground Ore, Flotation Tests

1—Reagents to laboratory rod mill.
  Test series with soda ash: soda ash, 4.0 lb per ton
    sodium cyanide, 0.06 lb per ton
  Test series with lime: lime, 5.0 lb per ton
  (See also laboratory grinding data)

2—Treatment before flotation as described in a, b and c.
  Note:
  The alkalinity dropped during agitation or aeration but in all cases the pulp had a pH of approximately 8, or higher during flotation.

Geophysics on the Pennsylvania Turnpike

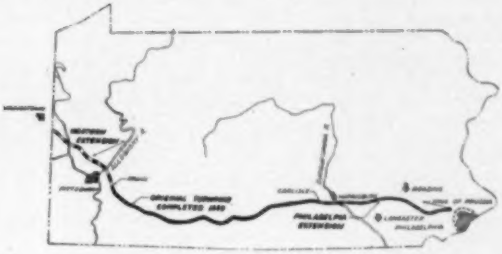

Fig. 1—Pennsylvania Turnpike system, Pennsylvania.

by H. LeRoy Scharon and A. B. Cleaves

The electrical resistivity method was utilized at 245 road cuts and structure sites over the 166 miles of the Philadelphia and Western Extensions of the Pennsylvania Turnpike System. Varying geologic structures and rock types afforded an excellent academic study of the method as well as a practical application to modern highway engineering.

THE application of geophysical techniques in the engineering surveys of the Philadelphia and Western Extensions of the Pennsylvania Turnpike System is unique inasmuch as this is the first time, (to the authors' knowledge), that such studies have been employed on a large scale on a major highway system.

These investigations were confined to specific areas along the center line of the proposed Philadelphia Extension between Carlisle and King of Prussia, and the Western Extension between Irwin and the State line near Youngstown, Ohio, as shown in Fig. 1.

Along the 100 miles of the Philadelphia Extension, the geophysical surveys were confined to 137 individual cuts and comprised a total length of 37.4 miles of line. The Western Extension, 66 miles in length, has 108 individual cuts. The accumulated length covered by electrical resistivity studies was 17.3 miles. The depth of the cuts varied from a minimum of 10 ft to a maximum of 62 ft.

The geophysical investigations were made for the purpose of determining depths to bedrock in the 245 proposed cuts and at the sites of various structures. The data also served as a basis for geological interpretations of the condition of bedrock, contact zones, rock types, water table, and other factors significant in highway construction.

The geophysical method of investigation employed the use of the electrical resistivity principle using the Gish-Rooney type electrical resistivity meter and the Wenner electrode configuration.* Apparent resistivities were determined for constant intervals to various depths and were correlated with surface geological observations and subsurface geological conditions revealed by key diamond drill holes situated within a given cut interval. From these correlations, depths to bedrock were postulated with notations on other geological features that might be pertinent to modern highway construction.

* F. Wenner, A Method of Measuring Earth Resistivity. U. S. Bureau of Standards *Scientific Paper 258* (1915).

Geology

The bedrock underlying the areas of the extensions of the Turnpike afford an excellent academic study of the electrical resistivity depth method as well as a practical application to modern highway engineering.

The rocks encountered on the Philadelphia Extension vary in age from pre-Cambrian to Triassic and Quaternary, whereas in the Western Extension, bedrock is confined to relatively flat-lying strata in the Allegheny, Conemaugh, and Monongahela formations of the Upper Paleozoic, Pennsylvanian. Glacial and Recent stream, valley, and terrace deposits are common.

Philadelphia Extension

The oldest bedrock encountered in this extension are igneous and metamorphic. These, encountered chiefly in Chester County, consist of the strongly

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contorted, banded Pickerihg gneiss which is in part graphitic and is locally injected by granite, quartz monzonite, diorite, gabbro and serpentine. Inclusions of the Franklin limestone are present. In general, the regolith is well developed over these rocks and swampy ground conditions are present in the area underlain by them.

The CambrianChickies quartzite is a ridge builder in this area. Along the Susquehanna River, downstream from Middletown, this very resistant rock stands as a cliff. However, in other areas, the cementing material between the individual sand grains has been removed by deep weathering. Consequently, although the topographic expression of a resistant ridge-building rock remains, solid rock in the true sense is lacking.

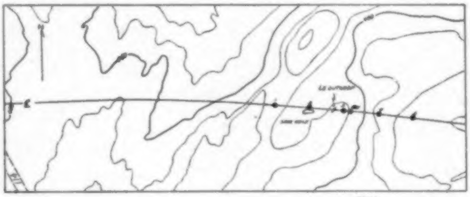
Cambrian and Ordovician limestones occur in Berks and Chester County near the eastern end of the extension and in Cumberland County near Middlesex. These limestones are strongly folded and fractured. Individual strata in the limestones vary greatly in solubility so that in a sequence of nearly vertical beds one stratum may crop at the surface of the ground whereas an adjacent stratum may be buried 30 or 40 ft in its own residium. Sinkholes in these strata are common and usually follow beds of high solubility.

Ordovician shales, Martinsburg in Cumberland County, and Cocalico in Lancaster County, show as brownish weathered, thin-bedded and strongly fractured and folded beds with a thin cover.

The most abundant rock throughout the Philadelphia Extension belong in the Triassic and consist of red clay-shales and interbedded, poorly cemented and arkosic-like sandstones and fine-grained conglomerates.

Diabasic sills in the Triassic vary considerably in grain size, and weathering characteristics. Diabase may outcrop in one spot and be weathered to great depths a few feet away. Where deeply weathered, the diabase may be said to be a relic soil. Where the sills are multiple and vary in grain size, one part of the sill may have a high moisture content and that part immediately adjacent may have a low moisture content. Commonly, within these relic soils unreduced remnants may remain as reasonably fresh rock.

Occasionally, along the northern boundary of the Triassic red sediments, faults between the Triassic and Paleozoic (Cambro-Ordovician) rock are encountered. Some have extensive development of gouge whereas others do not. The fault contacts were never observed in exposed sections but were drilled through on several occasions.



Western Extension

The rock strata in the area of this extension are of Pennsylvanian age and are relatively flat-lying. Except in glacial areas and along major stream courses the overburden is thin. The strata consist chiefly of micaceous sandstones, argillaceous sandstones, arenaceous shales, clay-shales, thin limestones, clays and coal beds. It is common to encounter firm sandstone layers underlain by clay-shales so weathered as to be essentially clays. In many sections the strata overlying mined-out areas have suffered subsidence with consequent fracturing and other disturbances.

Glacial outwash, terrace gravels, and recent sands occur along the margins of the Allegheny and Beaver Rivers and choke the valleys west of the Beaver River. The Allegheny River valley is filled with silt, sand and gravels up to 80 ft thick. On one island in the river on the proposed centerline, 66 ft of sands, gravels, silts and clays rest on a shale bedrock.

Examples of the application of the electrical resistivity measurements under these varying geological conditions consist of three on the Philadelphia extension and two on the Western Extension. These are: 1—Ordovician limestones, 2—Upper Triassic shales and sandstones, 3—Upper Triassic igneous rocks, 4—Pennsylvanian sandstones and shales, and 5—recent gravels and Pennsylvanian shale.

Geophysics

The Gish-Rooney type electrical resistivity meter and the Wenner configuration of electrode spacings were used in the determination of apparent resistivities to various depths at the sites of 245 proposed cuts and structures.

In the proposed cuts a total of 2347 separate station centers were located at intervals of 100 or 200 ft along the centerline and measured to depths varying from 18 to 180 ft. The measuring intervals varied from 1½ to 3 to 6 ft. The accuracy of interpretation is a function of the measuring interval. As nearly as possible, the line of electrode configuration was parallel to the centerline.

It is impracticable to discuss the results in all of the cuts; therefore, selected examples have been

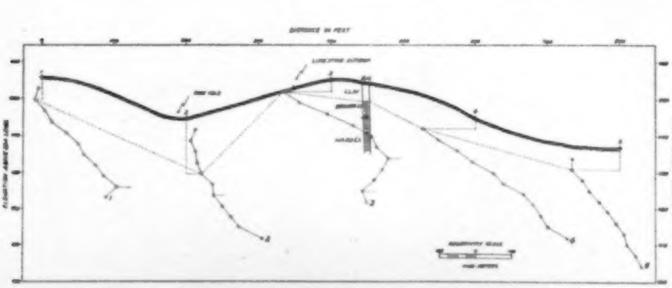


Fig. 2—Cut near Mechanicsburg, Cumberland County, Philadelphia Extension, Pennsylvania Turnpike.

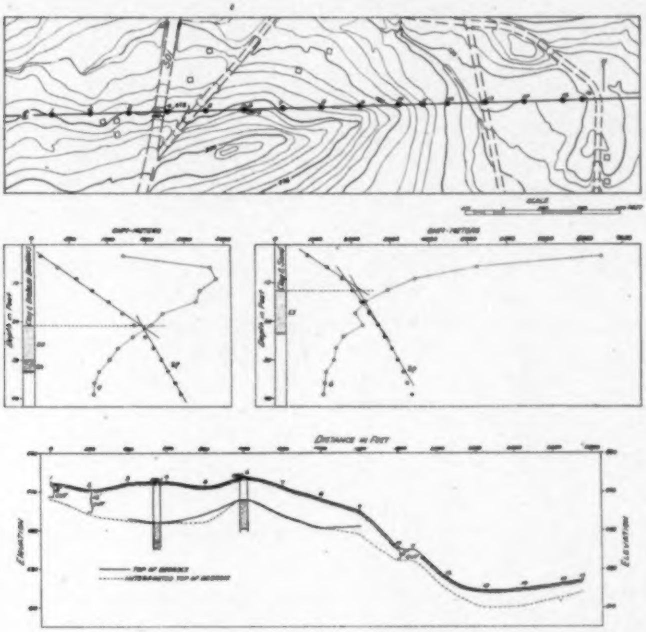


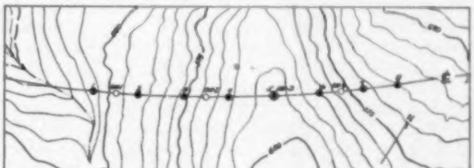
Fig. 3—Cut in vicinity of Route 501, Lancaster County, Philadelphia Extension, Pennsylvania Turnpike.

chosen, each representing different geological conditions and rock types to demonstrate the applications and results that may be expected under similar conditions.

Cambro-Ordovician Limestone

In a proposed cut near Mechanicsburg, Cumberland County, Philadelphia Extension, limestone outcrops and sinkholes occur in a matter of tens of feet from each other along the centerline, as shown in Fig. 2. These limestones are Cambro-Ordovician in age. The strata strike N45E, witnessed by trend of topography just west of station 1, and dip 29° to 50° southeast. In this particular cut-area, no ground water was reported.

Bedrock was determined in one borehole at a depth of 5 ft with sound rock at 9½ ft. An outcrop was recorded 100 ft west of the borehole and a sinkhole 150 ft further west. Five electrical resistivity stations were established at 200-ft intervals. Station 3, 50 ft west of the borehole, indicates bedrock depth at less than 3 ft (close to outcrop) whereas at stations 4 and 5 bedrock occurs at depths of 3 and 6 ft respectively. The tendency for the three curves to show a uniform increase in resistivity with depth indicate a fairly sound rock in the area east of the borehole. Station 2 was located at the sinkhole with bedrock interpreted at a depth of 15 ft but possibly at a depth of 21 ft. Station 1 indicated bedrock at 6 ft. The profiles for stations 1 and 3 show a sudden change in apparent resistivity trends at depths of



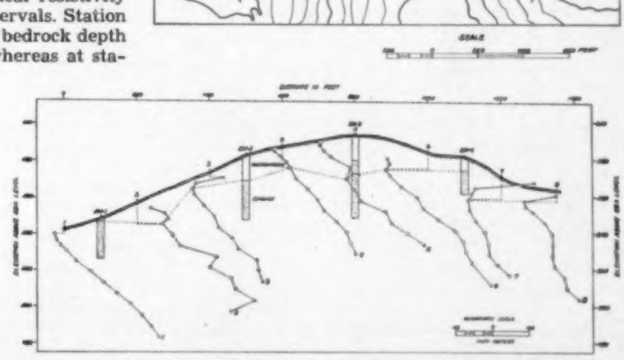


Fig. 4—Cut south of Lawn, Lancaster County, Philadelphia Extension, Pennsylvania Turnpike.

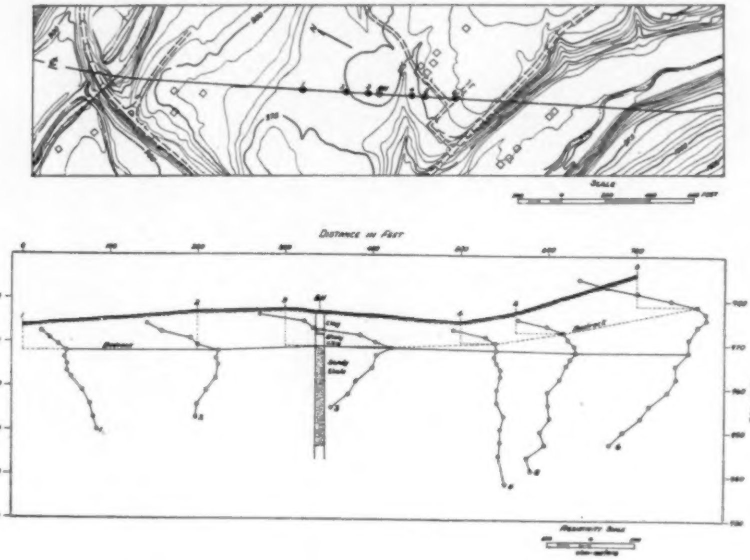


Fig. 5—Cut near Unity, Allegheny County, Western Extension, Pennsylvania Turnpike.

30 and 21 ft respectively. These breaks may reflect cavernous conditions in the limestone at these depths but most likely reflect the sinkhole area in the vicinity of station 2.

Similar analyses have been used in other limestone cuts along the centerline proving beneficial to preliminary investigations prior to actual excavation.

Upper Triassic Shales and Sandstones

In a cut adjacent to Furnace Run in the vicinity of Route 501 and west of Hopeland, Lancaster County, shales and sandstones of the New Oxford formation occur, see Fig. 3.

Two holes were drilled in this cut, recording an overburden of sandy and silty clay with occasional rock fragments and stray diabase boulders. Bedrock is sandstone at depths of 22 and 12 ft respectively.

The apparent and summation apparent resistivities for stations 4 and 6 were computed and correlated against the two drill holes as shown. Breaks on the apparent resistivity curves are not evident; however, breaks on the summation resistivities can be correlated against the drill results. These summation profiles were used principally as a means of interpretation of the 16 different points of observation.

A generalized cross-section indicating depth to bedrock is shown. From stations 1 to 10 the cut has been opened, and correlation between the actual and interpreted depths to bedrock was found to be remarkably in agreement within the measuring interval, here 3 ft. The stations 11 through 16 are in a fill area rather than a cut. Usually in areas of sandstones, the break between overburden and bedrock is sharp.

Upper Triassic Igneous Rocks

The highway centerline just south of Lawn, Lancaster County, crossed a zone of diabase intruded in the form of a sill into Triassic shales and sandstones parallel to the original bedding. All of the strata strike apparently N45E and dip between 40° and 45° northwest. The centerline over this rock roughly parallels the strike, as shown in Fig. 4.

An observation of the eight electrical resistivity profiles in this diabase area show changing resistivity characteristics from profile to profile. This was considered at first as reflecting strong jointing and fracturing. Interpreted depths to bedrock varied from station to station. Later, when the cut was excavated, it was found that depth to sound rock varied considerably and for the most part was much deeper than that recorded by the electrical measurements. The diabase, where deeply weathered, leaves a relic soil with extreme variations in moisture content. Within these relic soils unweathered, isolated remnants and "cupolas" remain as reasonably fresh rock. The drilling encountered these rather than the average depth level of solid rock. The excavation did confirm the resistivity results as to the thickness of the clay overburden and the contact of the diabasic

Table I. Reliability of Geophysical Method

Cut	Length, Ft	Geophysical Report, Ft	Actual Depth to Rock, Ft
A[a]	1500	10 to 13	8 to 9
B	200	No rock above grade	No rock
C[a]	300	9 to 10.5	No rock, 8 to 10 cut
D	700	8 (avg)	No sound rock. Compact shale and rotten sandstone varying in depth from 3 to 12.
E[a]	500	3 to 9	3 to 8
F[a]	550	9 to 17.5	10 to 13 (?)
G	1600	No rock	No rock
H	2900	12 to 18 (15 avg)	7.5 to 22.5 (15 avg)
J	1400	No rock	13 to 15 (?) Probably very little rock in cut.
K[a]	1600	No rock	No rock
L[a]	1525	7.5 to 21.0 (16.5 avg)	Shovel removing rock at average depth of 7 to 8

[a] These cuts investigated by electrical resistivity method without the aid of borehole data.

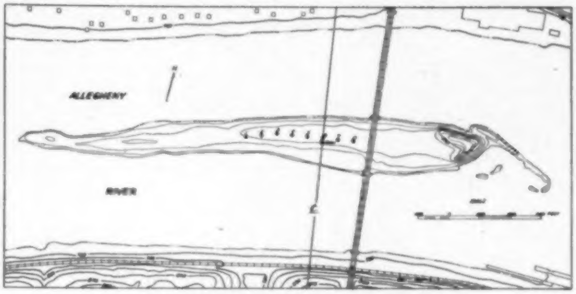
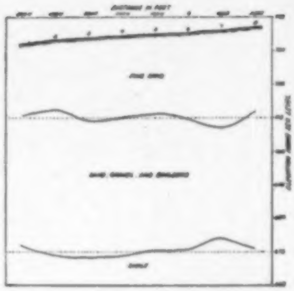
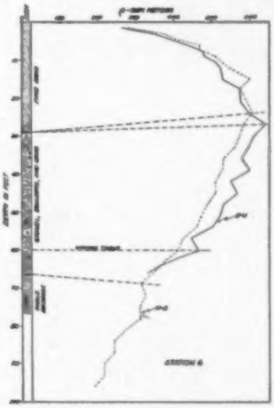


Fig. 6—14 Mile Island Bridge site, Allegheny River.





relic soil. However, the electrical work from a practical point of view was not helpful. It would be impossible to distinguish these fresh remnants in the relic soil by electrical measurements.

Even though the results were negative from a practical point of view, it did lead to a more detailed drilling program and critical review of other diabase areas.

Pennsylvanian Shales—Conemaugh Formation

A small proposed cut involving nearly horizontal strata of sandstones and shales in the Conemaugh formation was investigated near Unity, Allegheny County, see Fig. 5. Drilling of a borehole revealed a bed of sandstone underlain by a layer of shaly clay which was succeeded by a thick column of sound rock starting at a depth of 8 ft.

Six electrical resistivity stations were occupied with the resultant apparent resistivity profiles as shown. The depth to the top of the sandy shale formation was correlated with a down break in the resistivity profile at station 3. This type of break was correlated on the other profiles; however, it is believed that the sandy shale does not constitute bedrock throughout the entire cut. From stations 4 through 6, the depth to bedrock decreases, as witnessed by the correlation of the point shown by the broken line. In this interval, the sand horizon becomes thicker and the shaly clay pinches out, which is a common occurrence in these formations.

This cut has not been excavated to date; however, in areas of flat-lying rocks without the influence of pronounced structural features, it is reasonable to assume that the correlation of major resistivity "breaks" with stratigraphic units shown by core boring data are fairly accurate. A few of the cuts near Irwin have been opened with a remarkable agreement, within the measuring interval, between actual and interpreted depths to bedrock (about 1½ to 3 ft).

Recent Gravels and Pennsylvanian Shales

The centerline of the Western Extension crosses the Allegheny River at 14 Mile Island, as shown in Fig. 6. A high bridge crosses the river above this island, hence, knowledge of the depth of bedrock was essential.

A drill hole was drilled on the centerline with the log showing one horizon of fine sand succeeded in depth by a thick section of gravel, sand, and boulders with shale bedrock at a depth of 66 ft.

Eight resistivity station centers were located with the electrode configuration extending in east-west and north-south directions so that at each station two resistivity profiles were obtained. The profiles at station 6 are shown correlated with the drill log. Very definite breaks on the resistivity profiles correlated precisely with horizons in the drill log. On the basis of these characteristic trends, a vertical geological section was made along the line of resistivity stations showing the distribution of these sands, gravels, boulders, and depths to bedrock.

Reliability of Geophysical Method

Over Upper Triassic shales and sandstones, 11 cuts have been opened. A careful analysis has been made of the actual geological conditions and those reported on the basis of the electrical work. Table I illustrates the reliability of the geophysical work. It demonstrates that most of the interpreted depths were within the limit of error, which was 3 and 6 ft.

Caution is advised in acceptance of the electrical resistivity method as a complete tool by itself. The importance of basic geologic field work and corroborative core-borings is essential in such geophysical programs when applied to highway construction.

The accuracy of the electrical resistivity method in determining overburden thickness in the extensions of the Pennsylvania Turnpike System, as demonstrated in 104 cut sections (some excavated and all checked by core-boring data), is approximately 1.88 ft. This accuracy, in effect, takes the gamble out of bidding on "common" excavation for the contractor and is reflected in a low bid price with consequent saving to the owner.

Development of the South American Coal Industry

by Thomas Fraser

There are large coal reserves in Argentina, Brazil, Chile, Colombia, Peru and Venezuela, and growing productive industries in Brazil, Chile, Peru and Colombia. The paper describes current activities in these coal fields, and improvement programs that are in progress, or are planned. Special emphasis is placed on improvements in mining and preparation practice, and expansion of production that have been accomplished by American equipment and technical assistance.

UP to the present, there has been no large coal-producing industry in any of the South American countries. Since colonial times, the great mineral and agricultural wealth of that continent has led the people to activities other than the development of manufacturing industries based on coal; and climatic conditions are such that there has been very little demand for solid domestic fuel. However, there are extensive and widely distributed reserves of coal in South America that would make the development of a modern coal industry feasible. That factor is of the utmost significance now, when it is believed that the South American countries are entering the pioneer phase of a broad industrial development.

Coal Fields

Great areas of coal-bearing formations of Cretaceous and Tertiary ages occur generally throughout the Andean uplift and extend into the coastal range of the Caribbean region far east of Caracas. Thus the west coast countries have adequate reserves of coal, which include a wide range of types and classes.

In the eastern part of South America, east of the Cordillera, as in North America, the coal measures are of Carboniferous and Permocarboniferous ages. The principal known deposits in this area are in the southern States of Brazil. Permocarboniferous coals ranging in rank from lignitic to anthracitic are found in the States of Rio Grande do Sul, Santa Catarina, Parana and Sao Paulo. In the great interior plateau of Brazil, south of the Amazon River, are extensive areas of Carboniferous strata that may contain coal deposits. There are widely scattered reports of findings of coal in wells and stream beds in northern Piaui and Goias. In the Rio Fresco Valley, explorers have observed outcrops of two beds of anthracite and have brought to Rio de Janeiro samples from these beds. The Fresco is a tributary of the Xingu River that enters the Amazon from the south, but coal could not be shipped by water since the Rio Fresco area is in the upper part of the Xingu Valley, and there is a formidable series of rapids between that area and the lower level of the Amazon River basin. It is doubtful if coal deposits in this general area will be of economic importance for many years to come.

Fig. 1 shows the general location of known coal fields of South America that have been explored sufficiently to indicate the presence of workable reserves.

The coal deposits of the Andean region are similar in occurrence and general characteristics, as well as in age, to the coals of the Rocky Mountain region of North America. Although the coal fields obviously

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must be greatly disturbed by the tremendous Andean upheaval, there are evidences of large blocks of coal persistent over substantial areas. This applies particularly to explored areas in the coal fields of Colombia and Venezuela.

The coal measures of Cretaceous and Tertiary ages in the Andean area have been subjected to great tectonic influences, and there is even a wider variety of types of coal than in our Rocky Mountain section. On the other hand, the coal beds in the eastern part of South America are relatively less disturbed and are now persistent and uniform in thickness; in many locations they are substantially level.

Peculiarly, the similarity between the South American and North American coal areas is manifested further in the distribution of sulphur in the coal. The Andean coals are, for the most part, low in sulphur, presenting nowhere any difficult washing problem with respect to sulphur reduction, although they may vary greatly in ash content. On the other hand, sulphur is an important impurity in the Brazilian coals, and the characteristic occurrence of the sulphur varies greatly from area to area, as is so true of the coal fields of the Appalachian region of North America. For example, in the coking-coal region of the State of Santa Catarina, the sulphur often amounts to as much as 10 or 12 pct in the raw coal, but it can be reduced to 1.50 pct by washing—a remarkable washing performance. On the other hand, the coal deposits in the Rio de Peixe region of northern Parana, varying greatly in sulphur content, may have a large proportion of the sulphur in the organic and finely disseminated pyritic form. These coals do not respond well to the washing operation for sulphur reduction.

Fig. 1—Principal coal-producing fields of South America.

Reserves

In the present state of exploration and development of coal in South America, it would be futile to attempt to set up quantitative statistical data on tonnages of coal available in that continent. The coal resources of South America have only recently received serious attention, except in a very few localities, and the extreme difficulty of exploration in a large part of the area in which coal deposits occur makes it unlikely that thorough exploration and appraisal of reserves will be accomplished in the near future. In fact, with the present outlook for practical development of the coal industry and the expansion of the market in South America, such an expensive undertaking would not be justified. In most instances where coal is currently being produced, forward exploration work is sufficient to insure the availability of reserves adequate for present needs.

For these reasons, it is more practicable and probably more useful to treat the subject of reserves on a relative basis by classifying the South American countries and industrial communities with respect to the adequacy of available coal reserves, taking into account not only the information available with respect to the extent of coal deposits, but also the prospects of expansion of the need for the product over the foreseeable future.

Argentina, Brazil, Colombia, Chile, Peru, Ecuador and Venezuela very probably have adequate reserves of coal that can be developed to meet the needs of those countries over a long period of time, visualizing a normally rising curve of industrial activity; and these countries can supply coal to the international trade among the South American countries.

Of these countries, only Colombia, Peru, and probably Venezuela have adequate reserves of coal in a range of types and kinds that meet the needs of those countries in the development of a diversified industry over the reasonably long-term future.

Argentina, Brazil and Chile, on the other hand, while having adequate quantitative reserves, probably lack high-grade, special-purpose coals that would be needed in a modern industrial state. These countries must continue to import part of their coal needs for such purposes as gas-production and metallurgical operations.

Some occurrences of coal in Bolivia, Paraguay and Uruguay have been reported, but there are not at present known deposits of workable coal in those countries that would justify development of a mining industry to supply their fuel needs.

State of Industrial Development

Some recent data on the rate of production of coal in South America are presented in Table I. While most of the South American countries have ade-

Table I. Rate of Coal Production in 1948

Country	Tons
Argentina	62,000[a]
Brazil	2,013,000
Chile	2,239,000
Colombia	1,000,000[b]
Peru	187,000
Venezuela	21,000

[a] Asphaltites used as fuel.
[b] Estimated.

Fig. 2—Coal deposits of Argentina.

quate reserves of coal that would enable them to meet their fuel requirements from national production, only Chile, Colombia, and Venezuela currently are doing so. Chile and Peru have, from time to time, exported some coal to other South American countries, but on balance Peru generally has not produced as much coal as is consumed in that country.

In a few localities, namely the Arauco Bay area of Chile, and in the Sao Jeronimo area of the State of Rio Grande do Sul, Brazil, the coal-producing industry dates back into the 19th century. In these localities there are a few relatively large-scale producing operations with well-organized, systematic methods of mining and some mechanical equipment. Even in those countries, however, the small market for coal heretofore has not fostered any substantial expansion of the coal industry. Generalizing with respect to South America as a whole, the coal industry is in a pioneer stage, just entering upon the era of expansion. It may be considered, therefore, to be a virgin field of industrial activity. There are extensive reserves of virgin coal, and conditions favor the development of modern systematic coal-mining operations, starting without any inherited obsolete plant or practice. However, there are certain economic and social conditions that have a profound influence in practical developments. While coal mining in South America is decidedly in the pioneer phase with respect to physical operations, traditional methods of financing and organizing industrial enterprises are European rather than American. There are many obstacles to the organization of productive work in accordance with American practice to obtain large-scale, low-cost operation.

Most of the South American countries are well-advanced in the direction of liberal labor laws and social programs. While these programs, in most instances, come far short of complete enforcement in industry, they constitute a factor of substantial importance in planning a long-term industrial development.

This advancement of social legislation, far ahead of the actual realization of the complex industrial state to which it is adapted, presents an environment much different from that in which the beginnings of mechanized industry were successfully undertaken in the United States. Young industries will have to carry a relatively heavy burden of welfare expenses and regulatory restrictions during the critical proving phase, but these factors may be compensated by government supports and technical aids that were unheard of during the pioneer period of American industrial development.

With respect to governmental attitude toward the development of the coal industry in South America, almost every condition can be found ranging from complete nationalization of the industry on one end to entirely independent, free-enterprise operation on the other. In Colombia the annual production of coal, amounting to approximately one million tons, comes from at least 200 competing small producers; and it is still possible to start a coal-mining enterprise in that country with very little financial backing.

There is another factor that has a very great practical bearing on the development of South American coal industry; unlike the step-by-step pioneer development of the coal industry in the United States, expansion in South America is beginning at a time when prefabricated, complex, modern physical plants and production systems are being transplanted full-grown directly to the frontier.

Current promotional planning in South America is very largely directed to this type of development. Indeed, this concept is even more prominent in broad planning of general industrial development and is currently popular throughout the world. It is to be expected, therefore, that the South American industry will adopt the popular philosophy. In undertaking to apply American industrial knowledge, there is the problem of developing the most effective introduction of American technique under strange and varying social and economic conditions. On the one extreme, there is the traditional American pioneer method of modest beginning followed by gradual expansion, articulated with concurrent development of other industries as the general capabilities and needs of the community develop. On the other extreme, there is the forcing technique by which an attempt is made to advance a backward community in one leap to the ultimate in modern mechanical industrialization, using large capital sums supplied by government or government-supported agencies. The pioneer method would appear to be the more conservative and more certain of ultimate success. On the other hand, the forcing technique appears to offer the possibility of saving precious time in the development program—at a price. Many experiments are currently underway that should show, over a period of years, how real is this time saving and at how great a cost. Both

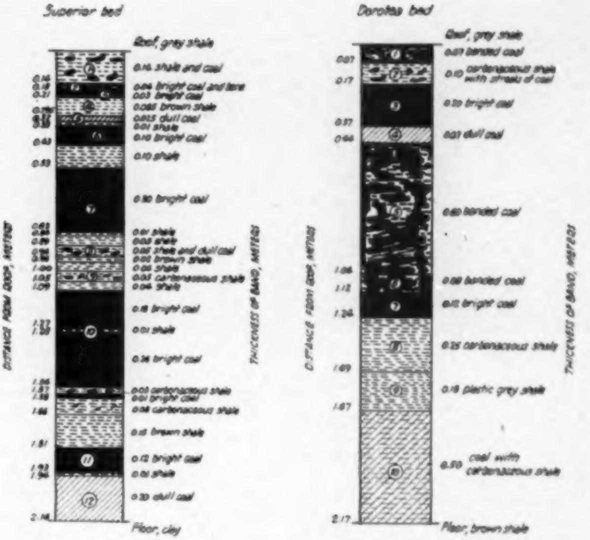


Fig. 3—Typical sections of coal beds in Rio Turbio field, Argentina.

types of development programs are in operation in the South American coal industry today, and there would be no better field in which to test the relative merits of these two systems by actual performance.

In South America, a modern industry must be built on a base somewhat different from ours—a base in which the principal elements are a new world wealth of natural resources; a new world frontier physical environment, and a people with an advanced "old-world" philosophy of life.

Transportation Facilities

In any coal-producing country, activity starts first where transportation facilities are available. Coal deposits in remote, inaccessible areas, no matter how extensive and no matter how high in quality, cannot be considered of any immediate economic value. This is especially important in studying the coal reserves of South America; the extensive coal-bearing measures are in the Andean countries, and there the terrain is so difficult for railway and highway construction that a relatively few miles of mountain terrain may constitute a definite obstacle to the development of a rich coal field while there is a relatively small potential market for the product.

Hence, the location of railways, which in colonial times were built to serve agricultural areas, and proximity of tidewater ports have been the determining factors in local development of small coal-mining industries. In South America this interdependence is intensified since the railways themselves furnish the most important market for coal.

Table II. Coal and Asphaltite Consumption in 1948, in Metric Tons

	Coal	Asphaltite
Railway fuel	673,000	8,000
Public offices	52,000	18,000
Utilities	614,000	7,000
Meat packing	67,000	
Industrial	45,000	14,000
Miscellaneous	126,000	5,000
Total	1,577,000	52,000

In several South American countries, more than half the total national consumption of coal is in the category of railway locomotive fuel, despite the tremendous quantities of wood used for firing locomotives. This predominance of the railway in the coal market perhaps will increase in the future as the expected increase in traffic and growing scarcity of timber force conversion of wood-burning locomotives to other types of fuel. Because of this dependence of coal-mine development upon the availability of local transportation, there are many instances of productive activity in coal deposits of minor extent and substandard quality explainable entirely on the basis of accessibility.

There are only five active coal-producing areas that are accessible to tidewater ports and in a position to export coal or to move coal from one point to another by sea. These five coal-producing areas are: 1—The central coal field of Chile adjacent to Arauco Bay; 2—the Santa River Valley anthracite region connected to the Pacific coast port of Chimbote by railway; 3—the Sao Jeronimo coal field of Rio Grande do Sul, Brazil, which ships coal to tidewater by the Jacui River; 4—the Santa Catarina coal field of southern Brazil, connected by railway to the Atlantic coast ports of Imbituba and Laguna, and 5—the Naricual coal field of Venezuela, connected by rail and by highway to the Caribbean seaport of Guanta. Substantial tonnages of coal have been dispatched through that port in the past, but the field is not operating at present. The Cauca Valley coal field of southwestern Colombia is served by the railway of the Pacific, which connects with the Pacific coast port of Buenaventura. However, no coal has actually moved out through that port for export. The

Table III. Sources of Energy in 1945, Pct

Petroleum and its products	26.1
Coal and coke	6.0
Wood and charcoal	34.4
Grain and farm waste	28.2
Gas	4.8
Hydroelectric power	0.4

Fig. 4—Miner working at face, Galeria No. 1, Rio Turbio Coal field of Argentina.

Photograph courtesy of U. S. Bureau of Mines.

Magallanes coal fields of southern Chile have a ready outlet through Punta Arenas, but no coal has been exported since early 1945, when the principal mine in that area was shut down. Exports before that time were to Argentina. Except for these fields, all capable of relatively small production viewed from our standpoint, the great reserves of coal in South America are in the interior and are currently being worked only in relatively small local areas to meet internal market demands. In most localities, the interdependence of the railways and the coal industry is very sensitive. Some railways are chronically short of fuel, and everywhere it is true that even a relatively small increase in railway traffic immediately creates a stringent bottleneck in the form of locomotive-fuel shortage. Hence, although coal is not generally recognized to be a strategic mineral, it almost immediately moves into the position of number one transportation problem in any general attempt to increase the rate of strategic mineral production.

Notwithstanding the relatively unimportant position of South American coal production in the world picture, the industry is growing in importance in almost every country; there have been some outstanding developments during the past 10 years, and many new projects are currently under development.

Argentina

There is no other South American country in which fuel shortage is so serious as in Argentina. The Argentine government is making determined efforts to develop a coal industry in the Rio Turbio coal field in the southern part of Patagonia.

Fuel Needs: Current needs of Argentina for coal and other solid fuels (except wood) are indicated by the consumption in 1948, Table II.

Currently, coal does not furnish a very large proportion of the total energy consumed in Argentina; but, if there is to be a marked industrial expansion in this country in the future, the energy load must be shifted in large measure to coal, as it is not to be expected that the supply of wood and agricultural products available for fuel is capable of any substantial expansion. Statistical data available up to and including 1945 indicate that, in round numbers, the total national consumption of energy increased from the equivalent of 9,657,000 tons of petroleum in 1939 to the equivalent of 12,500,000 tons of petroleum in 1945. Sources of energy as of 1945 are shown in Table III.

Practically all the coal consumed in Argentina is imported. Currently, this imported coal is furnished by Great Britain under the provisions of a commercial treaty recently completed between Argentina and Great Britain. The two central power stations of the Cadi Co. in Buenos Aires are currently receiving British coal at the rate of about 2000 tons daily. Although coal does not supply a very large proportion of the total energy used in Argentina, the importation of coal requires the expenditure of a substantial proportion of the foreign exchange available to Argentina. It is of the utmost economic importance to replace this imported coal, transported over a very great distance, by national production so that these large sums of foreign exchange may be diverted to the purchase of industrial machinery and miscellaneous manufactured goods for Argentina's expanding industries.

Coal Production: For many years the total production of solid mineral fuels in Argentina has been around 60,000 to 70,000 metric tons annually and practically all of this consists of asphaltites derived from mining operations in Mendoza and Neuquen.

There are also some small deposits of lignites and bituminous coals in these States and scattered in several parts of Argentina; but the only substantial reserve, so far explored, is the Rio Turbio field in the southwestern part of the territory of Santa Cruz. Fig. 2 shows the location of the known occurrences of coal deposits in Argentina.

Some years ago the Rio Turbio field was opened by agencies of the Argentine Navy, and a producing mine was placed in operation near the main camp established by the Navy on the Estancia Dorotea near the Chilean boundary. At present, the expansion of operations there is in the hands of a separate Government agency called Direccion General de Combustibles Solidos Minerales, and an ambitious five-year plan has been projected to establish a modern coal-mining industry in that area; to improve the port of Santa Cruz on the Atlantic coast of Argentine Patagonia to the north-

Table IV. Typical Analyses of Face Samples

Analyses	Dorotea Bed, Galeria 34	Superior Bed, Galeria 25
Moisture, pct	7.4	7.0
Volatile matter, pct	30.6	34.0
Fixed carbon, pct	44.0	46.0
Ash, pct	18.0	13.0
Sulphur, pct	1.67	
Calorific value, Btu	10,900	11,100

Table V. Brazilian Coal Production[a] and Imports,[b] 1940 to 1946, Metric Tons

Year	Brazilian Production	Imports	Total	Coke Imports
1940	1,048,533	1,185,904	2,234,437	23,338
1941	1,109,835	1,033,323	2,143,158	24,623
1942	1,354,089	592,761	1,946,850	23,277
1943	1,537,432	712,562	2,249,994	52,239
1944	1,414,607	709,957	2,124,564	12,208
1945	1,489,666	956,980	2,446,646	17,920
1946	1,273,708	1,002,620	2,276,328	11,506
1947	1,421,216	1,531,111	2,952,327	41,621
1948	1,423,399	1,060,150	2,483,549	22,817

[a] Cleaned coal available to consumers.
[b] Comparative heating values: 5 tons imported = 7 tons domestic.

Fig. 5—Coal fields of Brazil and known producing areas in the southern states.

east of the coal field; and to construct a railway to connect the coal field with that port. There is now an all-weather highway connecting the mining area with the port of Rio Gallegos on the Patagonian coast to the south of Santa Cruz; some coal has been shipped from this port to Buenos Aires and used in the Cadi power plants.

Rio Turbio Field: The Rio Turbio coal field is an area approximately 30 to 40 km long in a generally north to south direction and 15 km wide at the south and about 8 km wide at the north. It extends from near the Chilean border north of Natales on the south to the Estancial Cancha Carreras on the north. There are at least three coal beds of good working thickness, varying from 1½ to 3 m; and that part of the field that has been adequately explored by trenches, development workings, and drill holes is estimated to contain approximately 500,000,000 tons of recoverable coal.

These coal deposits are considered by geologists of the Direccion to be of early Tertiary age in the formation locally called the Patagonian. Presumably these coals are substantially of the same age as the deposits extending throughout the Andean region; these coal-bearing measures are in some of the countries considered to be late Cretaceous and in other countries they are designated as early Tertiary. The Rio Turbio coal beds outcrop along the western margin of the basin extending over the international boundary line into Chile in the south part of the area. Drill hole records show that the beds terminate underground along the eastern margin, indicating that this margin is the natural boundary of the basin in which the coals were originally laid down. However, exploration work has not proceeded far enough to prove definitely this hypothesis or to delineate the eastern extent of the basin precisely. It is held to be probable that there are other deep coal basins to the east, since the Patagonian extends to the Atlantic coast in that area and attains great thickness.

Typical sections of the two most valuable coal beds are shown in Fig. 3, and some examples of analyses of face samples of the coal are presented in Table IV.

A series of tests of the preparation characteristics of these coals carried out in the laboratories of the Direccion in Buenos Aires indicates that the Dorotea coal is somewhat more responsive to preparatory treatment than the coal from the Superior bed, but both coals may be readily prepared to serve as general purpose fuel.

It is the comprehensive plan of the Direccion, over the next five years, to develop several large, modernly equipped producing operations in the southern part of the Rio Turbio coal field and to build railway yards, shops, power plants, and other surface facilities around the terminal of the projected railway, which will be located in the Rio Turbio valley on the Estancia Dorotea.

There are now three underground operations in that general area—Galeria 1 in the Superior bed, Galeria 25 in the Superior bed, and Galeria 34 in the Dorotea bed. Galeria 1 is the original Rio Turbio mine opened by the navy. It is now on a production basis, worked entirely by hand, winning the coal at the face of chambers turned off the main Galeria and advancing to the rise. The coal picked from the breast by hand is delivered by gravity chutes to cars of

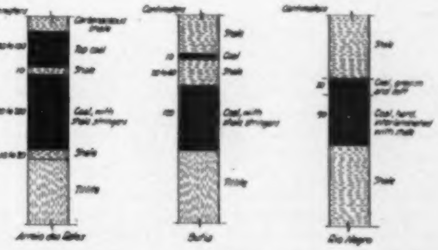


Fig. 6—Typical sections of coal beds in Rio Grande do Sul.

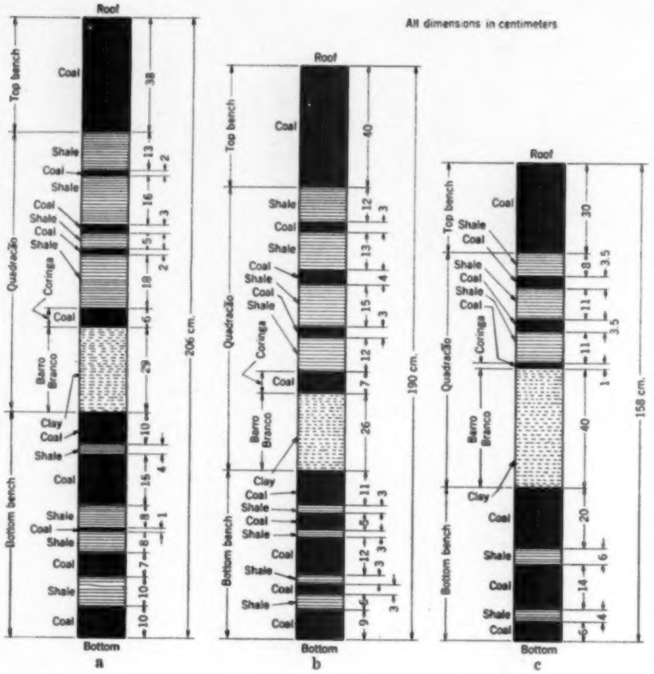


Fig. 7—Typical sections of Barro Branco bed in Santa Catarina, Brazil.

about 1000 kg capacity on the haulage road. Fig. 4 shows a miner working at the face of one of the chambers of the Galeria No. 1 mine.

Galerias 25 and 34 are in the development phase only and are designed eventually to open up important areas in these two coal beds near the proposed railway terminal.

During construction of the railroad, the general improvement program and development of mine workings will be carried on, and the coal produced during that period will be transported to the port of Rio Gallegos by steam lorries. The railway location survey has been completed, and it is currently reported that railway construction has been started.

Brazil

The coal-producing industry of Brazil is in the three southernmost States of that country—Rio Grande do Sul, Santa Catarina and Parana. There has been some small production in the State of Sao Paulo, but the known reserves there are so small that this State is not generally considered to be a potential coal producer.

As in Argentina, the largest load is carried by wood, and coal furnishes only a relatively small proportion of the total energy consumed. In fact, this condition is common throughout South America, with very few exceptions. In any sustained expansion of industrial activity in Brazil on a substantial scale, the increase in total energy would have to be supplied very largely by coal. Firewood production is generally considered to be at about the maximum that it can attain; and in some localities where the railways have depended for many years upon firewood for locomotive fuel, the supply is becoming scarce and costly. There are tremendous waterpower potentials in Brazil, but for a long time the nation's industries and its railway transportation system will be so widely dispersed that the capital investment required to serve these energy users with central station electrical energy would be prohibitive. Hence, a dependable source of coal supply of gradually increasing volume is of great importance to the future development of the economy of Brazil.

The coal needs of the nation have for a long time been supplied from domestic and imported sources, roughly in equal proportions, although this ratio varies from time to time as available foreign sources of coal have varied. Table V summarizes the available statistical data on the consumption of coal in recent years, broken between foreign and national sources of supply.

Reserves: The location of known coal reserves of Brazil is shown in Fig. 5. In some of the established producing areas, parts of the field have been explored by means of drill holes and exploratory openings, and these data have formed the basis of estimates of known reserves ranging variously from 380 million metric tons to 650 million metric tons. The data given in Table VI broken down by States are considered to be conservative.[1]

The data for the State of Santa Catarina refer only to the coal known to exist in the Barro Branco bed; no estimates are included for the Rio Bonito bed or for possible extensions of the Barro Branco bed beyond the areas explored by companies now producing. Estimates for Rio Grande do Sul likewise contain only the relatively well-known areas, and it is very probable that the conservative figure given here would be greatly expanded if explora-

tion work were continued in the Rio Negro field near Baje and in the Condeota valley.

Developments in Rio Grande do Sul: Brazil has one of the oldest coal-mining industries in South America, dating back to the opening of a small mine in Sao Jeronimo County in the State of Rio Grande do Sul in 1853; coal-mining activity has been carried on intermittently in that area until the present. At the beginning of World War II, there were two well-organized, sound mining operations in that field, one at the original mine location of Arroio dos Ratos and the other at Butia. Both operations are under the administration of the Consorcio Administrador das Empresas de Mineracao (CADEM) organized 1916.

These are the largest coal-mining operations in Brazil. The two mines are relatively near to one another in the eastern extremity of the crescent-shaped field shown on Fig. 5 just west of the city of Porto Alegre. In that locality the coal beds are not continuous, but the deposits occur in a series of isolated basins that attain a thickness of 5 to 9 ft in the central part, but thin out toward the edges. Fig. 6 shows typical bed sections at these mining properties and in the Rio Negro field in the south part of the State.

The deposits are opened by shafts and slopes, and all the coal is produced in underground mining operations.

At Butia, the room-and-pillar mining system is used, with some modifications. The use of mechanical mining equipment is limited to pneumatic puncher-type cutting machines and pick hammers. The cutting machines are generally used only in driving narrow work, while the pick hammers are employed in rooms as well as development headings. Endless rope haulage systems are used for underground transportation on the main haulage roads and the principal secondary roads. Loaded and empty cars are hand-trammed between collecting points and the face.

A modified longwall panel mining system is employed at the Arroio dos Ratos mine. The mechanical equipment underground is similar to that at Butia, except that electric trolley locomotives are used on the main haulage roads. The mine workings at both properties are ventilated by exhaust fans of the centrifugal type.

On the surface both these mining properties have modern American coal-preparation plants designed and built by the McNally-Pittsburg Manufacturing Corp. Both plants are combination picking table and Baum-jig washery plants adapted to prepare railway fuel and also to make a secondary coal which is delivered to the utilities company in Porto Alegre for use as power-plant fuel on chain-grate stokers and in pulverized-fuel burners.

Power for the productive operations and transportation facilities is supplied by coal-burning thermoelectric generating plants at each of the mines. The largest of the two plants, at Arroio dos Ratos, furnishes power to the municipality of Sao Jeronimo and to the port of Charqueadas.

Table VI. Estimate of Coal Reserves of Brazil, Metric Tons

Rio Grande do Sul	60,000,000
Santa Catarina	400,000,000
Parana	20,000,000
Sao Paulo	500,000
Total	480,500,000

Fig. 8—Hand preparation plant at Boinha mine.

Photograph courtesy of U. S. Bureau of Mines.

At each property, there are general machine shops, blacksmith shops, foundry, carpenter shops, electrical repair shops, and repair shops for rolling stock of the mine-transportation system. At Butia repair work also is done on railway rolling stock.

Black powder, the explosive normally used in the mining operations, is manufactured in company-owned factories at each of the two mines. Normal consumption is about 2640 lb of powder per day at each mine. Each of the two plants has a productive capacity of about 6600 lb of black powder in 8 hr.

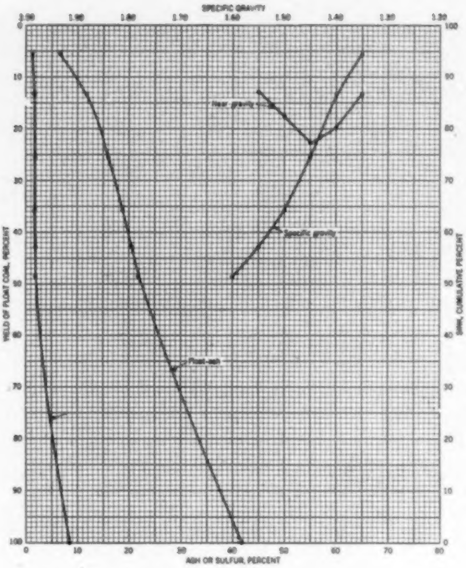
The company also operates a railway to the port of Charqueadas on the Jacui River and has loading facilities there by which coal is loaded into barges for transport to Porto Alegre, from there to be shipped by sea to other consuming areas of Brazil. Surface facilities of the Butia property include a 3600-m aerial tramway across the Jacui River at Condi. This tramway is used to deliver railway fuel to the State railways of Rio Grande do Sul.

This company has an advanced program of social benefits for the working people. There are adequate hospital facilities, schools and housing accommodations. Under the national labor code, the mine operates a 5-day week with four 6-hr shifts each working day.

For many years these two mines furnished the bulk of the national coal production. They reached a peak production record in 1943, when 1,346,269 metric tons was shipped. Since that time there has been a substantial decrease in the production rate, partly because the working areas have advanced into parts of the beds where mining conditions are less favorable, and partly because of the shortened work shifts coupled with a shortage of permanent labor.

To compensate for the threatened shortage of railway and industrial fuel in the State and for the rising costs of fuel, the Government of the State of Rio Grande do Sul in 1947 established a State agency called Departamento Autonomo de Carvao Mineral, under the direction of Jose Borges de Leao, to promote the production of coal on state-owned mining properties. This State agency is organizing a comprehensive program to develop the mining property of Leao in the same general area as the properties of CADEM and is also exploring coal deposits in other parts of the State.

Developments in Santa Catarina: The coal deposits of Santa Catarina, unlike those in Rio Grande do Sul, persist over large areas. The Barro Branco bed is mined extensively in the Lauro Muller, Urussanga, Criciuma, and Sideropolis areas. The Rio Bonito bed below the Barro Branco has not been



Specific gravity fractions	Elementary data				Computed cumulative data						Near gravity ±0.05 percent
	Weight grams	Percent			Float, cumulative percent			Sink, cumulative percent			
		Weight	Ash	Sulfur	Weight	Ash	Sulfur	Weight	Ash	Sulfur	
Float - 1.35		5.5	6.6	1.39	5.5	6.6	1.39	100.0	41.5	8.40	13.2
1.35 - 1.40		7.7	15.5	1.78	13.2	11.8	1.61	94.5	43.5	8.81	19.9
1.40 - 1.45		12.2	20.6	1.70	25.4	16.0	1.65	86.8	46.0	9.43	22.6
1.45 - 1.50		10.4	25.2	1.96	35.8	18.7	1.74	74.6	50.2	10.70	17.4
1.50 - 1.55		7.0	28.6	2.07	42.8	20.3	1.89	64.2	54.3	12.11	12.7
1.55 - 1.60		5.7	33.0	2.42	48.5	21.8	1.96	57.2	57.6	13.27	
Sink - 1.60		51.5	60.1	14.47	100.0	41.5	8.40	51.5	60.1	14.47	

Fig. 9—Washing characteristics of coal from Barro Branco bed. Size, 2 in. x 48-mesh.

explored, but it is generally thought also to be persistent and substantially level.

The Barro Branco coal bed, in which nearly all the producing mines are working, is a high-rank coking coal of medium-volatile content, but it is so intimately intermixed with shale and bony bands that the preparation of a usable coal is very difficult. Typical sections of this coal bed at operating mines are shown in Fig. 7.

Coal has been mined in this field for many years, but until the establishment of the national steel industry, the production was relatively small compared to Rio Grande do Sul, which dominated the national coal-producing industry. During the period of development and construction of the Government-sponsored national steel industry, a concerted effort was made to expand the production of coal in Santa Catarina, which is the only national source of metallurgical coal. The Brazilian National Government took many practical steps to support the coal industry in that area; and the United States Government, working through the Board of Economic Warfare, succeeded by the Foreign Economic Administration, and later the Bureau of Mines, cooperated actively with the National Government in these efforts, and several technicians furnished by the United States were resident in the coal field during that period. Stimulated by these efforts and by the expanding coal market furnished by the national steel industry, the production of coal in Santa Catarina increased from 268,213 metric tons in 1940 to 980,000 metric tons in 1946.

In 1940 there were a number of relatively small drift mines in the Criciuma area and a few somewhat larger operations, some of which were opened by shafts and slopes, in the Lauro Muller and Urussanga regions.

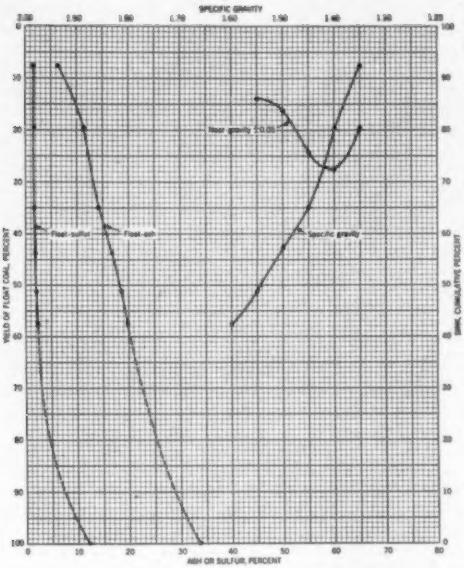
Throughout the area, the coal is won by hand at the face and loaded into small cars of 600 to 900-kg capacity and trammed by hand to the outside, except in the two or three largest operations. Until very recently, there were no central commercial power-generating stations from which the mines could purchase power, and only the largest operations had mine power plants. Because of almost complete lack of mining machinery, machine shops are confined to a few of the largest central units, and repair or maintenance shops at the mine proper are limited to small blacksmith shops for repair of hand tools. At most of the operations the only surface structures are open sheds of timber construction to house the screening and hand-picking operations. However, there are mine preparation plants at the Lauro Muller property of the Companhia Nacional de Mineracao de Carvao do Barro Branco at Lauro Muller, and of the Companhia Carbonifera de Urussanga at Urussanga. The Lauro Muller plant is equipped with piston jigs and coal-washing tables, and the Urussanga plant (of German design) is equipped with Schuchterman and Kramer-Baum jigs with feldspar in the boxes used for cleaning the fines. Both these plants are of small capacity. In addition, the Companhia Brasileira Carbonifera de Ararangua and the Sociedade Carbonifera Prospera each operates one Deister table for cleaning fines, and several hand jig plants are scattered through the field to handle fines at the rate of 0.5 to 1.0 tons per hr.

In the hand-picking plants, the coal is first screened by hand, then picked laboriously by hand on stationary tables and discharged to pit cars or bins from which the coarse coal is hauled, usually by trucks, to railway sidings from which it is again transferred by hand to railway cars. In the hand-preparation plants the coal is transferred from operating step to step by hand.

The total production of the field is gathered usually by trucks to sidings on the Dona Teresa Cristina Railway, which has branches to the three principal areas of the coal field, Lauro Muller, Urussanga, and Criciuma, and is transferred by this railway to the twin sea ports of Imbituba and Laguna from where it goes to market by sea.

National Steel Co.: This was substantially the physical condition of the Santa Catarina coal industry at the time of inception of the National Steel Industry development in 1940.

As a part of that program, the National Government empowered the National Steel Co. to purchase all the coal produced in the Santa Catarina field or such part of it as might be needed, and it established by decree a uniform price schedule that would insure profitable operation to the industry and encourage expansion of production; it empowered the National Steel Co. itself to acquire mining property and develop coal producing enterprises, and it authorized the Departamento Nacional da Producao Mineral to carry on extensive technical investigations in the Santa Catarina coal field, to establish working regulations and direct the use of employment in the area, and to construct water works and an experiment station in the municipality of Criciuma. The United



Specific gravity fractions	Elementary data				Computed cumulative data						Near-gravity ±0.05 percent
	Weight grams	Percent			Float, cumulative percent			Sink, cumulative percent			
		Weight	Ash	Sulfur	Weight	Ash	Sulfur	Weight	Ash	Sulfur	
Float – 1.35		7.6	6.3	1.33	7.6	6.3	1.33	100.0	33.4	12.07	19.5
1.35 – 1.40		11.9	14.8	2.08	19.5	11.5	1.87	92.4	35.8	12.93	27.4
1.40 – 1.45		15.5	19.9	1.86	35.0	14.2	1.86	80.5	38.9	14.54	24.2
1.45 – 1.50		8.7	23.3	2.21	43.7	16.9	1.93	65.0	43.4	17.56	16.2
1.50 – 1.55		7.5	27.0	3.31	51.2	18.4	2.13	56.3	46.6	19.94	13.9
1.55 – 1.60		6.4	30.2	2.49	57.6	19.8	2.18	48.8	49.5	22.40	
1.60 – Sink		42.4	66.2	25.51	100.0	33.4	12.07	42.4	66.2	25.51	

Fig. 10—Washing characteristics of coal from top bench of Barro Branco bed. Size, 2 in. x 48-mesh.

States Government assigned mining engineers and other technicians to cooperate with the Departamento Nacional in this program to stimulate the production of metallurgical coal for the steel industry.

As a result of these measures, new mines were opened and production was greatly increased, especially in the Criciuma area. Power plants, mostly of portable diesel-driven type with compressors, were installed at some of the mines and pick hammers were introduced in the underground work to speed up the production of coal and the extension of development work. Improvements in details of coal-handling operations were brought about in many instances to increase the productivity per man, especially among surface workers. An experimental hand-picking plant was erected by the Departamento at the Bainha mine, and substantial improvements were introduced to eliminate hand methods of transporting from unit to unit. This plant is shown in Fig. 8.

After extensive exploration work in the vicinity of the town of Beluno, the National Steel Co. acquired property there which contains substantial areas of Barro Branco coal adapted to open-cut mining and developed there the Sideropolis mine, which now produces approximately 10 pct of the total output of the Santa Catarina field. A large proportion of this tonnage is produced by strip-mining methods, using mechanical equipment obtained in the United States. Some underground operations are also being developed, and there is a surface preparation plant with large capacity storage bins and mechanical aids to the work that bring about a substantial increase in production per man as compared with the more primitive mine preparation plants described above.

Capivari Washery: Early in the development program, the National Steel Co. sampled the run-of-mine Barro Branco coal from the several coal-producing districts and sent a test lot of some 50 tons to the United States for washing tests and coking tests.

Based on test data obtained in the United States, the National Steel Co. erected a central coal-preparation plant in the railroad yards near the city of Tubarao to prepare the Santa Catarina coal to make metallurgical fuel. This plant site is near the junction point where the branch lines of the Dona Cristina Railway join to connect the coal-producing area with the Atlantic coast ports of Imbituba and Laguna. Here the steel company erected a 400-ton-per-hr washing plant of American design, furnished by the McNally-Pittsburgh Manufacturing Corp.

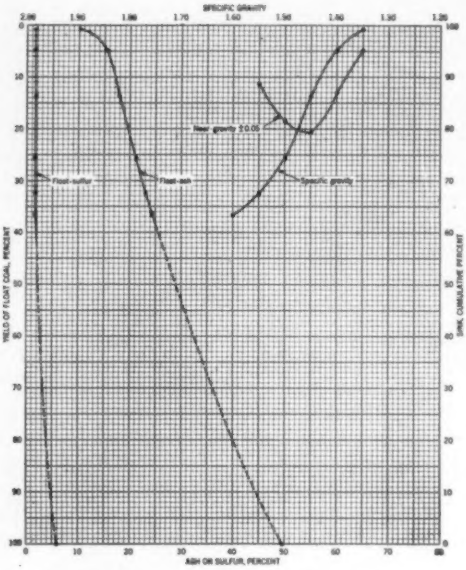
The Capivari washery is a combination Baum jig and Rheolaveur plant housed in a modern reinforced-concrete structure.

There is also a series of raw-coal storage bins in the receiving yards to receive and store raw coal obtained by purchase from the various producers in the Santa Catarina field. Besides serving as storage bins to furnish a continuous flow of raw material to the preparation plant, these bins must also serve as separate storage bins for the different producers. There is also a central power-generating station at Capivari to produce power for use in the preparation plant and for the coal producers in the Santa Catarina field. This plant is adapted to use secondary coal from the washing plant.

The Barro Bronco coal, though a very good coking quality, is extremely difficult to wash, and the yield of metallurgical coal is small. Therefore, it is necessary to make a three-product separation and to dispose of a large portion of the product as a general-purpose fuel coal of relatively higher ash content and lower heat value than the first-grade coal, which goes to the coke ovens of the steel plant at Volta Redonda.

A typical sample of the Barro Branco coal from one of the mines in the Criciuma area shows the preparation characteristics. The data sheet is reproduced in Fig. 9 and indicates the difficulty of preparing this coal for metallurgical use. Currently the Capivari washery is operating to produce a metallurgical-grade coal of about 22 pct ash content and is obtaining a yield of this grade of around 30 pct. Then there is a product amounting to 30 to 40 pct of the raw coal that is used in the power plant or shipped to market for industrial purposes. At the Volta Redonda plant, the Santa Catarina coal is blended usually with around 50 pct of high-volatile imported coal, drawn from eastern United States or Great Britain. Although this blend yields a coal of relatively high ash content, it is nevertheless well adapted for use in the blast furnace plant at Volta Redonda because the iron ore for this plant, obtained from the Minas Geraes iron range, is very high in iron content, and it is desirable to have a relatively large volume of coke ash to supply a slag volume adequate to slag off the sulphur, which runs about 1.5 pct in the coal.

Under the cooperative agreement between the U. S. Bureau of Mines and the Departamento Nacional de



Specific gravity fractions	Elementary data				Computed cumulative data						Near-gravity ±0.05 percent
	Weight grams	Percent			Float, cumulative percent			Sink, cumulative percent			
		Weight	Ash	Sulfur	Weight	Ash	Sulfur	Weight	Ash	Sulfur	
Float- 1.35	125.3	0.8	10.1	1.56	0.8	10.1	1.56	100.0	49.6	5.96	4.9
1.35 - 1.40	680.0	4.1	16.0	1.40	4.9	15.1	1.50	99.2	49.9	6.00	13.0
1.40 - 1.45	1470.0	8.9	19.3	1.44	13.8	17.8	1.50	95.1	51.4	6.20	20.5
1.45 - 1.50	1910.0	11.6	25.1	1.51	25.4	21.1	1.55	86.2	54.2	6.66	18.4
1.50 - 1.55	1130.0	6.8	30.0	1.66	32.2	23.0	1.57	74.6	59.2	7.47	11.2
1.55 - 1.60	730.0	4.4	34.0	2.55	36.6	24.3	1.69	67.8	62.2	8.03	
1.60 - Sink	10470.0	63.4	64.1	8.43	100.0	49.6	5.96	63.4	64.1	8.43	
	16515.3										

Fig. 11—Washing characteristics of coal from bottom bench of Barro Branco bed. Size, 2 in. x 48-mesh.

Producao Mineral, extensive tests of the washing characteristics of the Barro Branco coal have been extended throughout the field. These data have shown that the upper bench of that bed (above the middle bench called the Barro Branco), is relatively cleaner and much easier to wash to metallurgical grade than the bottom bench. It would probably facilitate operations at the Capivari washery if the two benches of the Barro Branco bed were mined separately, the top coal only to go to metallurgical use. In most of the underground operations, it is the current practice to handle these two benches of the bed separately at the face, and it is therefore not entirely impracticable to keep these two products separate where the mining and transportation is handled by hand, as is still the prevailing practice. Typical examples of the washing characteristics of the top bench and the lower bench of the Barro Branco coal are shown in Figs. 10 and 11.

Dona Teresa Cristina Railway: The expansion of coal production in the Santa Catarina field required substantial improvements in transportation facilities. The Dona Teresa Cristina Railway that connects the coal field with the coast was improved, and some new rolling stock was obtained, but the primary improvement that stepped up the capacity to haul coal was obtained by modernizing and greatly expanding the maintenance department so that the locomotives could be kept in service. Movement of coal also was facilitated by construction of a central railway loading bin in the railway yards at Criciuma, where raw coal may be loaded by gravity into railway cars.

Loading facilities at the twin ports of Laguna and Imbituba also were greatly improved. A loading station at the Imbituba port, erected in 1940, consists of a series of bunkers adapted to load by gravity chutes directly to ocean-going vessels. Belt conveyors distribute the coal to the bunkers and transport the coal from the railway dump-hopper to the distributing conveyors above the bunkers.

The Laguna facilities consist of an open storage yard along the waterfront with a concrete seawall and masonry quay upon which traveling cranes serve the boats alongside, loading coal from open storage behind the seawall.

Development in Parana: Exploration work was carried out in the northeast part of the State of Parana during World War II, and a small production was developed to supply fuel for the Rede Viacao Parana-Santa Catarina and the industrial area of Sao Paulo. The Parana coal beds lie in a number of small basins in the general area called the Rio de Peixe area which is served by the Rio de Peixe branch of the above-mentioned railway. The coal beds vary greatly in thickness and in quality, ranging from subbituminous to anthracite; however, the principal operating mines are in the bituminous coal. These mines are opened by drifts, but in the northeastern part of the field there are beds under about 330 ft of cover that would have to be opened by shafts.

During the development of these mines, the Rio de Peixe branch of the railway was extended to Euxebio Oliveira; it is proposed to extend that railhead to the center of the Rio de Peixe coal-producing area, but construction work is not yet completed. Inadequate transportation facilities have limited coal-production capacity. Mining and mine transportation are all carried on by hand, and preparation methods are very simple. Until 1946 practically all the coal was screened at about 1½ in., and the screenings were discarded. In 1946, the Companhia Carbonifera Brasileira installed a cleaning plant at its property and also put in a modern stoker-fired boiler plant to generate power. The preparation plant with screens, picking tables, and Deister tables washes the slack, producing a coal of around 14 to 18 pct ash content.

The peak production was reached at about 1945, when 79,856 metric tons of coal was shipped out of the Parana field. Practically all this coal was used as locomotive fuel by the Rede Viacao Parana-Santa Catarina and the Sorocabana Railway. Both these railways serve industrial areas that would be potential consumers of coal if production and transportation facilities were sufficient to make the coal available.

Chile

Chile has been a steady producer of coal for many years and has perhaps the most stable and modernly equipped coal industry in the continent. The record of production from 1938 to 1948, inclusive, is shown in Table VII. Chile is one of the few South American countries that is self-sufficient with respect to coal production. As indicated in Table VII, there is usually a small balance of exports over imports; the exported coal is usually sent to Argentina and Brazil.

The principal established coal industry is in the Arauco Bay area, where the production of coal was

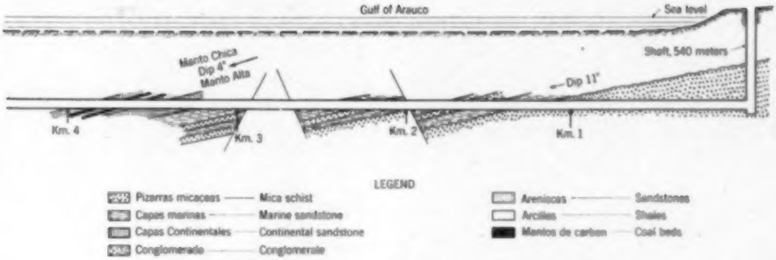


Fig. 12—Profile of the Piques Nuevos and gangways at Lota mine, Chile.

initiated in 1840 and has been continued intermittently since that date, with fairly steady production since 1935. The Lota mine and Schwager mine in the Arauco Bay area are the principal producers of coal in Chile. These operations were described by Toenges in a publication of the Bureau of Mines[2] reporting the findings of a technical mission sent to study the Chilean coal industry in 1944. Some illustrations in this text are taken from Toenges' report. The Lota and Schwager mines are developed by slopes and rock tunnels, and the workings in both mines extend under the sea. The method of working and relations of some of the typical workings to the coast line are shown in Fig. 12.

Metallurgical Coal: The Companhia Açero del Pacifico proposed to use coal from these mines to produce metallurgical coke and that projected development was the principal reason for the technical mission.[2] Samples of these coals, as well as some of the other Chilean coals were sent to the Central Experiment Station of the Bureau of Mines at Pittsburgh, where washing and carbonization tests were made. The Lota and Schwager coals are very low in fixed ash and sulphur and respond very readily to simple washing operations. Carbonization tests made by the Coal Carbonization Section of the Bureau indicate that these coals are moderately caking but make a rather weak, brashy coke, except when blended with low-volatile coals. Blended with 10 pct low-volatile coals, such as the Pocahontas No. 3, the Lota and Schwager coals perform similarly to the Sunnyside Utah coals in high-temperature coking. Float-and-sink test data and carbonization test data of a typical sample are shown in Tables VIII and IX.

There are other coal-mining operations in the Curanelahue, Lirguen-Cosmeto regions and in the Province of Magallanes. These have been described in detail by Toenges, and it is not necessary, therefore, to go into a descriptive treatment in this paper.

An estimate of available reserves of coal and lignite in Chile is given in Table X.

It is generally believed that there are extensive reserves of coal, as yet unexplored, in Magallanes not included in these estimates.

Colombia

The Republic of Colombia is considered to have the most extensive coal resources of any of the South American countries. Up to the present, the development of coal-producing industries has been purely local to satisfy the requirements of the internal market.

It is a peculiarity of this country that the centers of population and industry are in the interior and separated from the sea and from each other by mountain barriers that present such formidable obstacles of communication that these individual areas must be almost self-sufficient.

The most important of these industrial centers is on the great Bogota Plateau between the central and eastern mountain ranges. This is a community of miscellaneous small industries which have been expanding rapidly since 1940, and the local coal industry is almost the sole source of energy fuel. The demand is currently 40 to 50 thousand tons per month to supply the industries, the railways, and the domestic market. There is no continuous railway connection to the coast or to any of the adjacent

Table VII. Production and Movement of Coal in Chile, Metric Tons

Year	Production	Imports	Exports	Consumption
1938	1,838,000		58,000	1,780,000
1939	1,651,000		36,000	1,615,000
1940	1,740,000	221,000	32,000	1,929,000
1941	1,846,000	69,000	50,000	1,915,000
1942	1,921,000	17,000	86,000	1,852,000
1943	2,032,000	20,000	59,000	1,993,000
1944	2,279,000	16,000	46,000	2,249,000
1945	2,079,000	1,000	55,000	2,078,000
1946	1,954,000	3,000	39,000	1,912,000
1947	2,079,000	107,000	14,000	2,172,000

Table VIII. Typical Washability-Test Data of a Sample of Lota Coal

Specific Gravity Fractions	Weight, G	Weight, Pct	Ash, Pct	Sulphur, Pct	Yield of Float Coal, Pct			Cumulative Sink, Pct		
					Weight	Ash	Sulphur	Weight	Ash	Sulphur
Float, 1.35	52163.	98.52	2.28	0.71	98.52	2.28	0.71	100.00	2.72	0.73
1.35-1.40	298.	0.56	14.08	1.94	99.08	2.35	0.72	1.48	32.26	2.14
1.40-1.45	90.	0.17	16.11	1.44	99.25	2.37	0.72	0.92	42.97	2.26
1.45-1.50	57.	0.11	21.85	1.33	99.36	2.40	0.72	0.75	49.06	2.44
1.50-1.55	58.	0.11	24.50	0.90	99.47	2.42	0.72	0.64	53.73	2.64
1.55-1.58	12.	0.02	20.72	0.54	99.49	2.42	0.72	0.53	59.79	2.98
1.58-1.70	38.	0.07	36.92	0.70	99.56	2.45	0.72	0.51	61.33	3.07
Sink, 1.70	234.	0.44	65.21	2.45	100.00	2.72	0.73	0.44	65.21	3.45
	52950.	100.00								

Fig. 13—Coal deposits of Colombia.

industrial valleys and practically no movement of coal in or out of the intermountain Bogota area. A very small tonnage of foundry coke is shipped from the Bogota coal field to the industrial city of Cali; this moves over the central cordillera into the Cauca Valley by truck.

There are two other smaller, but still important, industrial areas in the interior—one around the city of Cali in the Cauca Valley between the western and central ranges, the other around the city of Medellin to the north. These two centers, like Bogota, consume the entire local coal production and depend almost entirely on that source for energy fuel. Only the cities of the Caribbean coast have access to foreign sources of fuel.

Development of the national coal industry will continue to be dominated by these geographical and physiographic conditions. While each of the three major coal fields will be limited to the local market, they may expect to be substantially free from competition from outside sources of fuel. The one exception is the Cali area in the Cauca Valley. The Pacific Railway connects this coal field to the Pacific coast port of Buenaventura, and the conditions in certain respects favor the development of an export coal trade from the Cauca Valley coal field through that outlet.

Table IX. Carbonization Test of 90 Pct Schwager Mixture with 10 Pct Pocahontas No. 3. Carbonizing Temperature 900°C.

Products	Yield[a]	
	Coal, Pct	Per Ton of Coal
Coke	65.2	
Gas	18.0	11,100 cu ft
Tar	6.0	12.5 gal
Light oil	1.27	3.48 in gas
Free ammonia	0.088	18.9 lb $(NH_4)_2SO_4$

[a] Coke, tar, ammonia, and light oil are reported moisture-free; gas is reported as stripped of light oil and saturated with water vapor at 60°F and under a pressure of 30 in. of mercury.

In the 1940 to 1950 decade, the Colombian coal industry serving these three industrial areas has expanded from an annual production rate of around 200,000 tons to 1,000,000 tons. This development has followed the traditional American pioneer pattern in that it has been financed purely by local capital, under local management.

The industry is now in the hands of many small operators; production methods are very elementary; all work at the face is manual; and there are only two or three operations where even animal haulage is employed. However, the industry is in a healthy expanding condition, is supplying coal to local industries at the equivalent of $3 to $5 per metric ton, and earning a reasonable profit.

The long-term outlook is for continued gradual increase in the demand for coal; therefore, a gradual expansion of coal production is indicated. A modest modernization program, with the first step limited to small-scale mechanization of haulage and outside transport, would greatly improve the economic conditions of the industry, but a large-scale mechanized American mining project introduced without regard to local market conditions would greatly disturb the economic balance.

Coal Resources: The geographical distribution of coal deposits in Colombia is shown on the map, Fig. 13, furnished by the National Ministry of Mines and Petroleum. The coal measures, of late Cretaceous or early Tertiary age, outcrop in all the three great mountain ranges of the Andean system. The most extensive and persistent known coal field lies along the western flank of the eastern cordillera, and it is known to extend through the states of Cundinamaraca and Doyaca and beyond in a northeastern direction to the Caribbean coast. It is generally assumed that the Venezuelan coal fields west of Lake Maracaibo are of the same general series. Throughout this area the local deposits have been subjected to varying tectonic action; and, locally the nature of the coal varies from subbituminous to low-volatile bituminous. In the Cundinamaraca and Doyaca areas, there are a great number of outcropping beds varying greatly in thickness, and in dip from almost level to vertical.

In the area of the Cauca Valley, between the western and central cordillera, the coal measures apparently lie in a broad synclinal fold with the beds outcropping in the mountain ranges on both sides of the flat Cauca Valley plain. The coal measures, carrying several beds that are practically vertical in the vicinity of the city of Cali, extend from that area in a generally north and south direction through the State of Cauca, almost to the border of Ecuador.

At Cali, where there are many small operations in the Golondrinas Mountain in the outskirts of the city, the coal is of high-volatile content, is hard and lumpy, and makes a very good railway-locomotive fuel and general-purpose fuel.

South of Cali, where there are many small mining operations in the mountain range west of the valley

Table X. Estimate of Reserves of Coal and Lignite in Chile, Metric Tons

Lota and Schwager concessions	100,000,000
Arauco Province, other	100,000,000
Concepcion Province	20,000,000
Valdivia and Magallanes Provinces	5,000,000
Total	225,000,000

Fig. 14—Coal deposits of Peru.

and along the Popayan Branch of the Pacific Railroad, there are low-volatile deposits. Such analytical data as are available indicate that the volatile matter gradually decreases to the south, and at a point some 20 to 30 miles south of Cali there are bituminous coals of 18 to 20 pct volatile that might be adapted to the production of metallurgical coke.

In the vicinity of Medellin, the coal deposits are of lower rank and generally are relatively thick beds, level or nearly level, and better adapted to mechanical mining than the deposits in the other two areas. These coals are of subbituminous rank, but relatively low in ash and free from interbedded impurities. The product is well-adapted to local industrial use and railway locomotive fuel. There is a strong demand for fuel in that area and the local fuel-burning industry is expanding.

It is obvious from the widespread distribution of coal, as shown in Fig. 13, and the extremely mountainous nature of the terrain in the coal areas that exploration is difficult. Only a relatively few important coal-producing areas have been examined, and no reliable quantitative estimates of total national reserves are available. Tentative and preliminary estimates, based on sketchy geological reconnaissance, have placed the total at as high as 80 billion tons of recoverable coal.

Current Developments: In the Paz del Rio area of the State of Doyaca, the Government of Colombia, through the agency of the Instituto de Fomento Industrial, is currently carrying on an extensive exploration and investigative program to appraise the reserves of iron ore, coal, and limestone adapted to furnish raw materials for a small iron and steel industry projected for that region. The Koppers Co. of Pittsburgh is doing work on coal deposits. It is reliably reported that there are adequate reserves of coking coal, including low-volatile varieties adapted to blending for a suitable coking-coal mixture. In the spring of 1949, L. E. Young, consulting engineer, of Pittsburgh, Pa., made an intensive study of the coal deposits in the immediate vicinity of Paz del Rio and Belencito where the projected plant will be located and proposed a plan for the development of coal mines on the LaChapa property to produce the fuel needed for the projected metallurgical industry. Dr. Young reports that it is practicable to develop adequate producing facilities there at reasonable cost.

Nearer Bogota, in the State of Cundinamaraca, production from the coal deposits of San Jorge is being expanded to furnish the fuel needed in an alkali industry being constructed in that vicinity by the Instituto de Fomento Industrial.

In current commercial mining operations in the Bogota field, the properties of the local Lobo-Guerero family have been equipped with some mechanical aids to production; and a simple screening picking plant is being installed at one of its mines, using equipment of American manufacture, to produce domestic coal for the Bogota city market where this company has well-equipped retail yards.

Currently, a study of the possibilities of developing an export industry, based on the Cauca Valley coals, is being made by the Instituto de Fomento and the national railways of Colombia in cooperation with the U. S. Bureau of Mines, represented by a mission sent to Colombia under the terms of Public Law 402, establishing a fund for cooperative scientific work with the American Republics. This program involves a study of the characteristics of the local coals, the local market trends, and the feasibility of producing and transporting low-volatile coal to seaboard for export.

Peru

The coal situation in Peru differs from most of the other coal-producing countries in South America in that the internal demand is very small and that the capital and the principal railway are readily accessible to foreign coal through the Pacific coast port of Callao. Hence, the national coal-producing industry is definitely on a competitive basis, even in the domestic market, and must produce coal at a cost comparable to that of foreign producers. At present, the internal market is further affected

Table XI. Proximate Analysis, Sulphur, and Calorific Values of Some of the Samples of Ancos and La Galgada Anthracites

Sample No.	Description	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	Btu per lb*
112	1.70 float, J bed	4.40	3.40	87.10	5.10	0.80	13,774
212	1.70 float, G bed	4.15	3.25	82.70	9.90	0.69	13,082
312	1.70 float, I bed	3.80	3.85	84.45	7.90	0.69	13,505
412	1.70 float, H bed	3.90	7.05	82.00	7.05	0.70	13,829
512	1.70 float, F bed	4.10	4.35	84.55	7.00	0.91	14,092
612	1.70 float, ⅛ in. x 0 r.o.m.	4.75	5.35	84.25	5.65		13,081
622	1.70 float, ¼ x ⅛ in. r.o.m.	4.90	6.10	83.85	5.15		13,905
632	1.70 float, ½ x ¼ in. r.o.m.	4.60	5.70	84.95	4.75		13,995
642	1.70 float, 1 x ½ in. r.o.m.	4.67	3.55	87.00	4.78		13,799
662	Hand-picked 3 x 1½ in.	5.15	4.55	84.70	5.60		13,729
672	Hand-picked 3 in. lump	4.77	4.53	84.95	5.75		13,678
712	1.70 float, Descubierto bed	5.10	2.30	85.50	7.10		13,241
812	1.70 float, Animas bed	4.65	3.00	85.80	6.55		13,479
912	1.70 float, Balcon bed	8.50	2.65	81.95	6.90		12,811
1012	1.70 float, Esperanza bed	4.85	2.55	86.65	5.95		13,478
1112	1.70 float, Presticio bed	5.00	2.70	87.75	4.55		13,680
1412	1.70 float, Pinta bed	5.38	2.60	85.90	6.12		13,381
1512	1.70 float, Cancha bed	5.20	2.60	84.35	7.85		13,153
611	Raw ⅛ in. x 0 dust, La Galgada	3.45	6.90	57.75	31.90	0.98	10,112
621	Raw ¼ x ⅛ in., La Galgada	4.20	6.10	71.40	18.30		11,909

* Calculated by Goutal's formula, Calories = 82 C + aV.

Table XII. Carbonizing Tests of Oyon Coal (Yields of Carbonization Products, As-carbonized Basis)

Test No.[a]	Retort Diam, In.	Carbonizing Temperature, °C	Yields, Weight of Coal, Pct[b]							Yields per Ton of Coal[b]				
											Light Oil, Gal			
			Coke	Gas	Tar	Light Oil	Free Ammonia	Liquor	Total	Gas, Cu Ft	Tar, Gal	In Gas	Tar to 170°C	$(NH_4)_2SO_4$, Lb
279	13	900	83.7	10.2	2.3	0.43	0.099	1.7	98.4	10200	4.7	1.19	0.08	8.7
279A	13	900	68.1	15.9	5.2	0.78	0.114	7.2	97.3	10450	10.7	2.12	0.68	20.3
75	18	900	82.8	11.1	1.8	0.48	0.127	3.6	99.9	10300	3.5	1.32	0.05	11.6

[a] 279 100 pct Peruvian coal.
279A 20 pct Peruvian coal and 80 pct Sunnyside coal
75 100 pct Pocahontas No. 3 coal.
[b] Coke, tar, ammonia, and light oil are reported moisture-free; gas is reported as stripped of light oil and saturated with water vapor at 60°F and under a pressure of 30 in. of mercury.

adversely with respect to coal by a special price set-up on fuel oil under the terms of contract under which the petroleum concessions are being operated.

Currently, the national coal industry is limited to two specific enterprises, the operations of the Cerro de Pasco Copper Co. at its coal-mining property Goyllarisquisga and the anthracite mines in the Santa River Valley near the seaport of Chimbote in northern Peru.

In 1947 the production of bituminous coal amounted to approximately 140,000 tons, and the production of anthracite was 80,000 tons. The bituminous coal, practically all of which was mined at Goyllarisquisga, was used by the Cerro de Pasco Copper Co. for railway-locomotive fuel and for its smelting operations at Oroya. The anthracite production was practically all stocked at the properties of the producing mining companies; but there were some export shipments of a trial nature, and some coal was taken by coastwise vessels for bunker fuel.

The Anthracite-Producing Industry: Development of the anthracite-producing industry depends almost entirely upon the demand of foreign markets. The most promising outlet would appear to be Argentina and possibly the Far East. Some shipments have been made to both of these destinations. There is a gradually developing, but very small, domestic market principally in Lima. Currently the sole household use for coal is for cooking purposes, and the competitive fuel, as elsewhere in South America, is charcoal. Some of the producers have been active in developing small cooking stoves and grates adapted to use anthracite, and there is a large potential market but one that will be very difficult to develop.

Reserves: The principal known coal-bearing areas in Peru of practical importance are shown in Fig. 14 from an unpublished report prepared by Frank E. Wagner, for the Banco Minero del Peru. The anthracite region of northern Peru near the coastal port of Chimbote includes the Huayday and Santa River Valley fields. In the Huayday field, the anthracite mining production of the Northern Peru Mining Co., at the rate of 150 tons a day for some years, was used at the copper mines and the smelter at Quiruvilca. These beds are similar to those now being worked in the Santa River Valley area at La Galgada and at Ancos. In the Galgada-Ancos field there are a number of parallel and almost vertical veins ranging from 1 to 3 m in thickness, outcropping in the mountains between the Chuquicara and Ancos Rivers and extending south of Ancos. These beds, of Cretaceous age, are highly metamorphous and approach the graphitic stage in some areas. The volatile matter ranges from 3½ to 7 pct. Somewhat farther south, at the Mina Lord on the Santa River, the volatile ranges from 7 to 9 pct. There the bed dip is only about 20° to 30° from the horizontal.

From this northern anthracite field of Peru, the coal-bearing measures, of Cretaceous age, outcrop in a large area throughout the Andean region extending in a generally southeasterly direction across Peru and into Bolivia. There are numerous outcrops and other evidences of anthracite at many locations in the Ancos-Galgada-Limena area and extending beyond the falls of the Canon del Pato and into the upper Santa Valley where, following the outcrops of the Cretaceous farther south, the coals are of higher volatile content, changing to high-volatile bituminous in rank.

The coal deposits at Goyllarisquisga being worked by the Cerro de Pasco Copper Co. are of bituminous rank and relatively high in ash. The proven reserves are relatively small but nevertheless adequate for the immediate needs of the producing company.

In Peru, as in Colombia, the location of active coal mines is determined more by geographical and physiographic conditions than by the quality of the coal available. The Goyllarisquisga property is accessible to the Cerro de Pasco railway, and the product is adaptable to the uses of the company for locomotive fuel and general industrial purposes.

Other potential coal fields in the interior, indicated on the map, have been known in a general way for many years, and some very small operations

Table XIII. Physical Properties of Coke (Columbus Steel Corp. Methods)

Test No.	Retort Diam, In.	Carbonizing Temperature, °C	True Specific Gravity	Apparent Specific Gravity	Cells, Pct	Shatter Test				Tumbler Test			
						Cumulative Pct Upon				Cumulative Pct Upon			
						1½ In.	1 In.	¾ In.	½ In.	1½ In.	1 In.	¾ In.	½ In.
279	13	900	1.92	0.87	54.7	68.2	94.2	97.1	98.0	46.6	78.8	82.8	85.6
279A	13	900	1.93	0.81	58.0	57.6	90.2	95.0	97.5	36.0	75.1	81.8	86.1
276				0.75		43.2	75.1	83.5	92.4	20.1	55.1	65.1	75.8

279 100 pct Peruvian coal.
279A 20 pct Peruvian coal and 80 pct Sunnyside coal.
276 100 pct Sunnyside coal.

produce coal for local use. These are only indicative of the distribution of potential coal reserves throughout that general part of the country. Northeast of Lima, in the Oyon coal field, the Government of Peru through the agency of the Banco Minero, made extensive exploratory openings for several years and developed a substantial tonnage of low-volatile coal that would be readily adapted for use in the production of metallurgical coke; but these deposits are not now accessible to transportation facilities. The very rugged terrain presents formidable obstacles to railway or highway construction.

On the Paracas Peninsula south of Lima, there are thought to be extensive deposits of bituminous and subbituminous coals located favorably for the development of transport facilities that would make these coals accessible to the seacoast. However, only preliminary reconnaissance surveys have been made, and while these surveys indicate the presence of substantial reserves and some analyses show the product to have good fuel coal value, no consistent development program has been undertaken owing primarily to lack of market demand and capital resources.

Outside of the Cerro de Pasco Copper Co. operations at Goyllarisquisga, the most extensive exploration work has been done in the Galgada-Ancos-Limena anthracite field, and it may be safely estimated that approximately 1½ million tons of anthracite have been proved. Persistence of the principal beds over fairly substantial distances in the area that has been adequately explored, together with numerous observations at many points throughout the region where these beds outcrop, or are opened up by local exploratory drifts, justify the assumption that there are very large probable reserves of anthracite in that area, probably running into billions of tons; but there are no adequate exploratory data to support any definite quantitative estimates. In the nearby future there is no foreseeable market development that would justify further exploration. In the present development of the industry, the proven reserves may be considered adequate.

Technologic Development: In the Santa River Valley field, a Government-sponsored program, being carried out by the Corporacion Peruana del Santa and Banco Minero del Peru, contemplates the development of an anthracite-producing industry there in connection with a broad industrialization program that might be called the Santa River Valley project. This plan provides for eventual construction of a steel plant, cement plants, electrolytic zinc refinery and a general industrial area around Chimbote Bay, the expansion of agricultural activities in the Santa River Valley, and rehabilitation and improvement of the Santa Railway, all powered by the coal industry, and a hydroelectric power plant now under construction at Canon del Pato where the Santa River breaks through the Black Range from the upper valley to the coastal plain.

These Government agencies have been active in supporting the privately owned coal-mining industry, consisting at present of three active operations, Mis Suenos mine at La Galgada, Ancos mine on the Ancos River near Galgada, and Mina Lord at Limena on the Santa River farther south. The principal project of the Government, besides improving the transport facilities furnished by the Santa Railway, has been the construction of a modern breaker and preparation plant in the immediate vicinity of the port of Chimbote, intended to serve as a central customs separation plant to handle the output of the mines along the railroad.

Fig. 15—Preparation plant at Ancos mine and view of Ancos river canyon.

Photograph courtesy of U. S. Bureau of Mines.

This plant, of American design and construction, provides for screening and cleaning the coal as in typical Pennsylvania anthracite practice, using Parrish-type shakers for sizing and Chance-sand flotation cones and hydrotators for washing the product. This plant only recently has been placed in operation, and a cargo of prepared coal from the plant has been shipped to the Argentine for a test. A 20,000-ton open storage bin and modern piers in the harbor of Chimbote Bay, built by the Frederick Snare Corp. for the Corporacion Peruana del Santa, will furnish loading facilities for transferring the washed product to seagoing ships in the harbor.

There are also small preparation plants at the Mis Suenos mine and at the Ancos mine, where some coal was prepared for shipment before the central washery at Chimbote was completed. Fig. 15 shows a general view of the Ancos River canyon and the washing plant of the Ancos mine. On this property the veins are vertical; they outcrop in the mountainside on each side of the canyon and are opened by drifts at approximately the valley level.

Operations at Mis Suenos mine are similar, except that the development openings are on the mountainside at perhaps 1000 ft above the level of the valley of the Chuquicara River.

At Mina Lord, at Limena on the Santa River Branch of the railway some 10 miles above the Chuquicara junction, the veins, which dip at approximately 20° from the horizontal, are opened by parallel entries driven in the coal on the strike and connected by cross entries on the dip. Before the Chimbote central washing plant was completed, coal produced was accumulated in a stock pile at the mining property. This stock pile, which aggregated

Fig. 16—Experimental coke ovens in Oyon region, Peru.
Photograph courtesy of U. S. Bureau of Mines.

approximately 80,000 tons, is now being transported to Chimbote and prepared in the central breaker there for shipment.

An investigation of the preparation characteristics of the anthracites of the Santa River region, carried out in 1945, indicated that these anthracites are readily cleanable to a good market grade and are similar in physical characteristics to our Pennsylvania anthracites. Complete data on this study of Santa River anthracites are presented in a Bureau of Mines publication.[4]

A tabulation of the principal analytical data on representative samples of the various coal beds is presented in Table XI.

In the Oyon region, an aggressive development program carried out for the Banco Minero del Peru under the supervision of Frank Wagner of Wilkes-Barre, Pa., resulted in the exploration of several workable beds of low-volatile, high-rank bituminous coal. Small-scale coking operations carried out in this region in some special retorts developed and built by the engineering organization of Branco Minero indicated that this coal is a strong coking coal adapted to produce a metallurgical fuel. Fig. 16 shows a view of this experimental carbonizing plant.

Supplementing this work, the Bureau of Mines made carbonization tests of this coal and of blends with high-volatile coals from Sunnyside, Utah. These tests indicated that the Oyon coal is a good product for such coking-coal blends. A typical test report from R. I. 4222,[5] showing the experimental data of a carbonization test of a blend of 20 pct Oyon low-volatile coal with 80 pct of the Sunnyside coal, are given in Tables XII and XIII.

Because of a lack of transportation facilities, active development work in the Oyon region has been discontinued pending financing and construction of a railway or highway that would make this region accessible to the sea through the Huara River Valley or to the Cerro de Pasco railway.

Venezuela

Venezuela is not now an important coal-producing or coal-consuming country. The very extensive and profitable petroleum industry currently overshadows any possibility of economic importance of coal. However, for the long-term future, the extensive reserves of coal probably available in that country may form the basis of an industrial development that will greatly broaden the economic structure and make the general conditions more stable.

For many years, a Government-owned coal industry in the Naricual River Valley, east of Caracas, produced coal for the use of the Venezuelan Navy. Since April 1946, when a violent explosion occurred in these mines, production has been discontinued.

At present, the most important producer of coal is the San Jose mine at Lobotera in the State of Tachira, south of the Lake Maracaibo region. This operation, producing coal for local use, has been expanding rapidly in the past three years, and in 1948 the production was estimated at some 21,000 tons.

There are outcrops and small exploration openings showing coal at many locations in western Venezuela in the Peninsula west of Lake Maracaibo and extending over the line into Colombia, and around the head of Lake Maracaibo to the south and on islands in the lake. These deposits, reportedly of Tertiary age, vary from lignitic to low-volatile bituminous, and their value for long-term future economic development is enhanced by proximity to the sea and by some evidence that these coals might be suitable for metallurgical use. Deposits are known in the six western States of Zulia, Tachira, Merida, Trujillo, Lara, and Falcon; the north-central States of Aragua and Guarico; and at least three localities in the eastern State of Anzoategui.

The Naricual coals likewise have the great advantage that they are very near to the sea and, in fact, are connected to the seaport of Guanta by a railway and an improved highway. There are also port facilities with mechanical equipment for loading coal into seagoing vessels at this Caribbean seaport, a power plant located in the railway yards at Barcelona to supply power for the railway and mining operations, and a small briquetting plant at the same location. At present, all these facilities are in an indeterminate state of repair, and some major repairs probably would be necessary to rehabilitate the general mining and transportation plant.

Although operations thus are relatively unimportant, the Government of Venezuela is very conscious of the importance of developing a coal industry or at least of an appraisal of reserves and possible economic importance of these sources of wealth. It is planned, therefore, to make a general reconnaissance of the coal fields and a study of possible uses of this product in the future development and possible industrialization of Venezuela.

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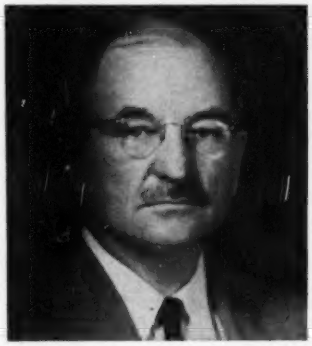
aime NEWS

E. D. Gardner Named 1951 Chairman of MGGD

Eugene D. Gardner, chief mining engineer for the Bureau of Mines in Washington, D. C., was named, at the AIME Annual Meeting, to head the



Mining, Geology, and Geophysics Division in 1951. He succeeds **Philip J. Shenon** in the post.

Taking his B.S. in mining engineering from the University of Utah in 1905, Mr. Gardner joined the Bureau of Mines in 1911 as a mineral examiner for the forest service in the Northwest. He was attached to the safety division in Pittsburgh, and in Berkeley, Calif., moving to Tucson in 1922, and becoming superintendent of that station three years later. In 1915 he received an E.M. degree from his *alma mater*. While at Tucson, he conducted many studies of both blasting and mining methods and began a prolific career of technical writing. Mr. Gardner's supervisory activities underwent a big expansion in 1939 with appropriation of funds for the development of strategic minerals. In 1945 he went to the Bureau's oil shale mining division in Denver, heading the division two years later. It was in 1949 that he was appointed chief mining engineer for the Bureau in Washington. Mr. Gardner has been an AIME member since 1912, and a leading contributor to AIME publications.

Institute Supports Engineering Activities

For the first time in 1950 AIME made a contribution totalling $1050 to the Engineers' Council for Professional Development. The ECPD has in the past received contributions from other founder societies and its most successful accomplishment has been its accrediting program for curricular in engineering colleges.

A smaller contribution by AIME has been made to the Engineers' Joint Council. Mr. Robie has served as Secretary of this organization. EJC has been active in urging a policy for conservation, development, and use of the national water resources. Also, it has been working toward the establishment of an Engineering Manpower Commission.

The United Engineering Trustees has been looking for a new home for the founder societies during the past year. No definite developments have been reported.

Change of Address

When notifying AIME headquarters of a change of address, or of company position or affiliation, *please mention the Branch of the Institute to which you belong—Mining, Metals, or Petroleum*. This will make for a more expeditious handling of the change and will facilitate the preparation of various reports.

De Re Metallica Delayed

If a copy of the Herbert Hoover Translation of De Re Metallica was recently ordered, please be patient while awaiting delivery. Production problems will delay mailing until the end of April.

R. E. Byler Appointed MBD Chairman For 1951

Raymond E. Byler (left) is shown being congratulated at the Annual Meeting on his appointment as 1951 Chairman of the Minerals Benefícia-

tion Division by **Grover J. Holt**, retiring Chairman of the Division. Mr. Byler, now vice-president of the Merrill Co. in San Francisco, has been with that company for over 15 years, as a metallurgical and chemical engineer in consulting work, research, and development. His experience includes many years in the metallurgical and chemical process field covering operation, research, and development of processes and equipment, and the beneficiation of base metal and precious metal ores. He was engineer in charge of process development and plant design and technical supervisor of operations of two plants built and operated by Merrill for the production of magnesium powder and aluminum powder during World War II. He holds a B.S., with honors, from the University of California, and has a total of 25 years' experience in design and construction of plants and development of processes and equipment for beneficiation of ores in Mexico, the western United States, and Canada. An AIME member since 1924, Mr. Byler served as last year's Associate Chairman of MBD.

Spring Meetings Announced By Industrial Minerals Division

Two meetings in April will be drawing industrial minerals-minded engineers and geologists to opposite ends of the continent. The first is the Canadian Institute of Mining and Metallurgy industrial minerals program, Apr. 9 to 11, and field trip to asbestos mines and mills Apr. 12 and 13. The second is the Northwest Industrial Minerals Conference, Apr. 27 and 28, which is being sponsored by the Oregon Section, AIME in cooperation with the Columbia and North Pacific Sections and the Industrial Minerals Div.

G. F. Jenkins, Chairman of the CIMM Industrial Minerals Div. and Vice-Chairman AIME Industrial Minerals Div. extends a cordial invitation to AIME Industrial Minerals Div. to send representatives to the CIMM meeting which will be held at the Chateau Frontenac, Quebec City. The industrial minerals part of the program is as follows:

Tuesday, Apr. 10, am, *Asbestos Research.* M. S. Badollet, Research Center, Johns-Manville Corp. *Perlite.* N. B. Davis, consulting mining engineer, Ottawa. *Manufacture of Portland Cement.* W. S. Weaver, Canada Cement Co., Ltd.

Wednesday, Apr. 11, am, *Selection and Use of Lightweight Aggregate.* G. S. Matthews, Industrial Minerals Div., Mines Branch, Ottawa. *Ball Clay Operations of Saskatchewan Minerals, Ltd.* J. C. Ward. *Potential Sources of Alumina in Canada.* W. K. Gummer, Aluminum Laboratories, Ltd. *Nova Scotia Diatomite.* M. R. Foran, Dept. of Chemical Engineering, Nova Scotia Technical College.

A 2-day post-convention tour of the asbestos mines in the eastern townships of Quebec will follow the meeting.

Northwest Industrial Minerals conference will be held at the Congress Hotel, Portland, Ore., according to Ralph S. Mason, Chairman for the meeting. Friday, Apr. 27 will be devoted to technical sessions and social affairs. Richard J. Anderson of Battelle Memorial Institute will address the luncheon on the function of Battelle and what services it can perform for western industrial minerals producers. The guest speaker at the banquet, which will be preceded by a cocktail party, will be A. B. Cummins, Chairman Industrial Minerals Div., AIME, and manager of research for Johns-Manville Co., Manville, N. J. Dr. Cummins will speak on "Asbestos—A General Review" and his talk will be followed by a color film on asbestos mining and milling technology. On the following day, Saturday, Apr. 28, a series of field trips have been arranged to view industrial minerals plants in the Portland-Vancouver area.

The papers scheduled for presentation are as follows: Consumption of Industrial Minerals in the Pacific Northwest (3 papers): *Inland Empire,* Don W. Walters, managing engineer, Inland Empire Industrial Research Inc., Spokane. *Lower Columbia River,* A. O. Bartell, Raw Materials Survey and Ralph S. Mason, Oregon Dept. of Geology and Mineral Industries. *Puget Sound* (tentative).

Industrial Minerals Used in the Northwest Paint Industry, James G. Hohn, Van Waters & Rogers Inc., Portland. *Dimensional Change Studies of Unit Masonry,* J. J. Weggner, Washington State Institute of Technology, Washington State College, Pullman, Wash. *Concrete Aggregate Preparation at Detroit Dam,* Woodrow L. Burgess, Corps of Engineers, U. S. Army, Portland District; plus color sound 17 min film "Operation Concrete". *Recent Advances in Industrial Minerals Beneficiation,* James A. Barr, Chemical Div., Armour & Co. *British Columbia Industrial Minerals* (tentative).

Drift of Things . . . . as followed by **Edward H. Robie**

NEW York City often is considered an expensive place in which to live and do business, so the suggestion is frequently made that AIME headquarters be removed elsewhere. This impression perhaps is attributable largely to the fact that New York has lots of visitors, and visitors and strangers to any city almost always pay more for what they receive than do the home folks. They patronize hotels and restaurants instead of living at home; and the restaurants they visit are not usually those that the natives have found economical and good.

Traveling about the country a bit, as we have had to do, and maintaining an office and publishing a magazine in Dallas as well as in New York, we have come to the conclusion that the AIME would save no money if its headquarters were in some other city. The expense of removal would be considerable, and an almost completely new staff would have to be trained. Present contacts with other engineering organizations would suffer greatly or be much more costly.

Evidence that prices in New York are not high compared to other cities has just been compiled by the Bureau of Labor Statistics. It studied an urban worker's family budget in 34 cities in October 1950. This is as good a guide as any to the comparative cost of doing business in those cities, for where living costs are high, business costs are in proportion. The 34 cities rank as follows:

Washington	100	Milwaukee	100	Richmond	99
Houston	99	Atlanta	98	Seattle	97
Boston	97	San Francisco	97	Los Angeles	97
Memphis	96	Jacksonville	96	Pittsburgh	96
Baltimore	96	Detroit	96	Chicago	95
Denver	95	Cincinnati	95	Minneapolis	95
Norfolk	95	Birmingham	95	Portland, Ore.	94
Philadelphia	94	Buffalo	93	Manchester	93
New York	93	St. Louis	93	Cleveland	92
Portland, Me.	92	Scranton	92	Indianapolis	92
Savannah	91	Kansas City	90	Mobile	89
		New Orleans	88		

Thus, New York is really one of the cheaper cities of the country in which to live. Washington is the most expensive, which should occasion no surprise. Its cheap taxi fares create a good first impression which unfortunately does not persist. Costs of living are, of course, less in country towns, but the AIME would have to function quite differently if its headquarters were in an inaccessible place.

Writing the Drift this month while at home in bed with *la grippe*, we have had a chance to glance at the current "Atlantic." Turning first, as we are wont to do, to the most highly intellectual departments, we notice, in *Accent on Living*, that Austria is the cheapest country in Europe open to Americans, with rather fantastic prices compared to the U.S.A. If we are going to move, let's move.

Adieu to James R. Finlay

A generation or two or three ago, one of the most prominent names in American mining was that of James Ralph Finlay. Death claimed him on Jan. 1. He had led the usual active life of a leading mining engineer, with work all over the world. He was a writer of distinction, too. Engineers of the older generation seem to have been more inclined to authorship than do those of the present day. Finlay's *Cost of Mining* is a classic. Within the year he had visited our office bringing with him the manuscript of what would be a two-volume work, partly autobiographical and partly technical and economic.

Just two weeks and two days before Finlay died he wrote a letter to his old friend, Milnor Roberts, of Seattle, from which the Dean has given us the privilege of quoting:

"I keep wondering about our position in the world. My notion is that we talk too much about communism, which I take to be essentially a recrudescence of the old idea of an absolute monarchy. In this view it is easy to understand that within the area in which Russia is now dominant it is more congenial and more intelligible than is our capitalistic democracy, of which all the people east of the Alps and the Mediterranean know next to nothing. Neither the Russians nor any of the other inhabitants of their present sphere have the same culture as the Western nations who developed our civilization, and we have never had very much to do with them. That is, a sort of iron curtain has always covered that part of the world.

"What I think our people fail to realize fully enough is that the basic impulses that we have to contend with are not so much communism as the old nationalism and radicalism that have always been there. The Chinese very naturally want to get us out of Korea, and to get the French out of Indo-China, just as we would want to get an Asiatic nation out of Central America. Southern and eastern Asia have wanted to get rid of West European domination—the colonial system—communism or no communism. In short, we might say we are opposed by a kind of continentalism.

"I thought I could see, as far back as 1943, that Russia probably would court the Germans, just as we would, and try to marshal the old world against the new. Just now we are combatting them where they have the advantage. In general, we have the advantage in the air. We can control the sea. Our interest is to keep the world open to trade, travel, information, and opinion. The iron curtain is an affront to civilization, and the expression of an inferiority complex. But if we can hold the sea and the air and maintain access to 80 pct of the habitable world, communism will get stale and insipid. If we make so much of it, we glorify it, advertise it, and give it the appeal of a Hollywood movie star.

"The zealots of every revolution think they are going to conquer the world. None of them have ever done it.

"That, I think, is where we stand, in a general way. It doesn't pay us to have our boys fighting guerillas in the jungles and mountains of Asia."

And From a Young Man

A somewhat similar view, expressing doubt of the validity of our foreign policy, from a man some 60 years younger, was published in *The New York Times* of Sunday, Mar. 4. It was written by Marine Corporal John B. Moullette from Camp Pendleton, Calif. Among other things, he complains about the extravagance of our Government and the needless waste of life in Korea, on both sides, "shameful to the human race." Not only the loss of life there, but the wreckage of the country and the destruction of the homes of the people are said to have made Americans as unpopular, even among the South Koreans, as the Communist invaders from China.

Corporal Moullette's letter was answered by his father, and also by Dean Acheson, the whole occupying some five columns in the *Times*. The answers seemed to us inadequate.

A profligate Government in Washington whose income has equalled its expenditures in only one of the last 20 years and whose foreign policy has failed so dismally that we are compelled again to have recourse to the law of the jungle, may well call forth protests from the young men. It is they, and not the men who have brought the world to its present condition, who must pay the price of failure.

Personals

Horace M. Albright, president of U. S. Potash Co., New York, has been reelected chairman for the National Minerals Advisory Council.

Robert A. Blake, formerly employed as metallurgist for the American Smelting & Refining Co., Leadville, Colo., is now at the Mike Horse zinc mine in Montana.

Vearle W. Balderson, ordnance engineer, St. Louis Ordnance Plant, Salt Lake City has been transferred to St. Louis.

M. Howard Berliner has resigned from the Eagle-Picher Mining & Smelting Co., Tucson, to accept a position with the U. S. Geological Survey, Joplin, Mo.

J. L. Black has joined the Zinc Corp., Broken Hill, N. S. W., Australia.

Arthur E. Bernard, formerly state inspector of mines, was appointed warden of the Nevada State Prison, Carson City, Nev.

A. Keith Butler is now located at Newcastle, Australia as manager for the Broken Hill Proprietary Co., Ltd. He had been located in the company's New York City office.

Philip R. Bradley, Jr., mining committee chairman and president of Pacific Mining Co., San Francisco, has been named consultant for the Defense Minerals Administration and acting chairman of the Civilian Commodities Committee for manganese, chromium, and tungsten.

Howard Caddy is chief engineer for the Inter-State Iron Co., Virginia, Minn.

Donald F. Campbell is now located at Rua Barao da Torre No. 443, Ipanema, Rio de Janeiro.

T. E. Charley, formerly of Henderson, Ky., is now employed by the Joy Mfg. Co. at Claremont, N. H.

Leonard C. Clark is no longer associated with the Bradley Mining Co., Stibnite, Idaho. He is presently self-employed, operating a small pumice property at Fallon, Nev.

John Dasher has been appointed project engineer of the Chemical Construction Corp., New York. He was formerly executive officer of the MIT mineral engineering laboratory, Watertown, Mass.

Douglas D. Donald, mining geologist, has joined the New Jersey Zinc Co., Austinville, Va.

ALLEN H. ENGELHARDT

Allen H. Engelhardt is assistant manager of operations at Cerro de Pasco Copper Corp., La Oroya, Peru. He was associated with the South American Development Co., Guayaquil, Ecuador for the past 20 years.

R. J. Ennis, general manager and vice-president of the McIntyre Porcupine Mines, Schumacher, Ontario, has retired after 40 years of service.

Charles R. Fettke has been named professor of geology at the Carnegie Institute of Technology, Pittsburgh.

George Gordon Fleisher has left the employ of the American Smelting & Refining Co., Silver City, N. Mex. and may be reached at Coalinga, Calif.

Edwin R. Goter is the new mill superintendent at the Foote Mineral Co., Kings Mountain, N. C.

Henry G. Grundstedt has joined the Christmas Copper Corp., Christmas, Ariz.

Vincent A. Haak has been named surveyor for the Yuba Consolidated Gold Fields, Hammonton, Calif.

Richard N. Hunt is now geologist for the U. S. Smelting, Refining & Mining Co., Salt Lake City.

Walter C. Keil has been appointed assistant superintendent in charge of smelting operations for the Federated Metals Div., American Smelting & Refining Co., Newark, N. J.

A. J. Keast, general manager of the Zinc Corp., Ltd., Broken Hill, Australia for the past 15 years, has resigned to become general manager of the Australian Aluminum Production Commission.

Nestorio N. Lim has resigned as chief of the Mining & Metallurgical Div., Bureau of Mines, Manila to become secretary-treasurer of the Chamber of Mines in the Philippines. He was also reelected chairman of the Philippine Section, AIME.

J. F. Linthicum, who retired from active management of the American Lumber & Treating Co., Chicago, will continue as a director. He has been with the firm for the past 14 years.

James I. Moore, Jr., formerly located at Mt. Pleasant, N. C., is now residing in Hillsboro, N. Mex.

Harry W. Marsh and **W. L. Zeigler** have been appointed to a National Advisory Committee on lead. Mr. Marsh is secretary of the Idaho Mining Assn., Boise, and Mr. Zeigler is general superintendent of the Pend Oreille Mine & Metals Co., Metaline Falls, Wash.

Robert B. Mahan is manager for the Scranton Consolidated Mining Co., Ainsworth, B. C., Canada. He was transferred from Klemath Falls, Ore. and is presently engaged in the development of zinc, lead, gold, and silver claims.

STANLEY M. MOOS

Stanley M. Moos is opening a branch office of the Ponsford-Moos Equipment Co. in Mexico City, D. F.

George E. Morris has become associated with the Chile Exploration Co., Chuquicamata, Chile.

Clarence O. Mittendorf has joined the staff of the Defense Minerals Administration as director of production expansion. He was formerly director of the Economic Cooperation Administration mission in Turkey.

Lowell B. Moon has been appointed chief of the Minerals Div. of the Bureau of Mines. He succeeds **Joseph H. Hedges** who has been appointed special assistant to the bureau director.

ALAN PROBERT

Alan Probert, assistant director, Foreign Minerals Region IX, Bureau of Mines, is now located at Washington, D. C. He had been stationed in Mexico City.

F. C. Menk is director of engineering for the Island Creek Coal Co., Holden, W. Va.

Wilfred E. Nagel has joined the Aluminum Co. of America, Los Angeles, as metallurgist.

Kenneth W. Nickerson, Jr., McElroy Ranch Co., has been transferred to Midland, Texas, from Breckenridge.

Alfred E. Niemi, assistant drilling and blasting foreman, Phelps Dodge Corp., has been transferred from Ajo, Ariz. to Lowell.

Daniel T. O'Connell is associate professor of geology and chairman of the Geology Dept., City College of N. Y. He is serving as consultant to the State of New York Building Code Commission.

R. V. Porritt has been appointed general manager of Noranda Mines, Toronto. He succeeds **H. L. Roscoe** who will continue as vice-president of the company.

Lawrence T. Postle will become vice-president and general manager of the Granby Consolidated, Copper Mountain, B. C. At present he is manager of the East Sullivan Mines in Quebec.

Morton E. Pratt, Jr. is now working with the trench unit, American Smelting & Refining Co., Patagonia, Ariz.

L. Fern Pett has been appointed general superintendent of mines, Kennecott Copper Corp., Bingham Canyon, Utah.

Harold A. Quinn has joined the staff of the Geological Survey of Canada,

Dept. of Mines & Technical Surveys as a geologist. He was recently awarded a Ph.D. in geology at Cornell University.

Jerome M. Quets may now be reached at Elisabethville, Katanga, Belgian Congo.

A. E. Ruddick is retiring as assistant mill superintendent at the Chaupi concentrator of the Cia Minera Unificada Cerro de Pososi, Potosi, Bolivia. His new address will be Bank of London & South America Ltd., 5-6-7 Tokenhouse Yard, London.

Robert G. Reeves is now geologist for the U. S. Geological Survey, Reno.

H. R. Rice was recently appointed editor of the *Canadian Mining Journal.* He succeeds **R. C. Rowe** who will continue as editor-in-chief.

Bindeshwari Narain Sinha has left for Calcutta, India, where he will be assistant geologist, Geological Survey of India.

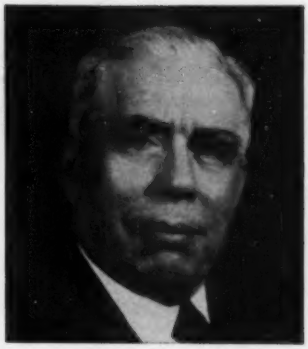
D. S. Sanders has been appointed concentrator superintendent in the Sulphide Div., Chile Exploration Co., Chuquicamata, Chile.

Frank N. Spencer has resigned as chief engineer and geologist for the Cia Minera Aguilar, Argentina, to accept the position as resident mining engineer for the Cerro de Pasco Copper Corp., New York.

Obituaries

Allen H. Woodward (Member 1900) died on Nov. 26, 1950. Mr. Woodward was born in Wheeling, W. Va., in 1876. He attended the University of the South and M.I.T., graduating in 1899. Following graduation he joined the Woodward Iron Co. as a locomotive fireman and engineer. He became superintendent of furnaces, general superintendent, and general manager. Later he was made president and chairman of the board. Other business connections included posts as director of the Wheeling Steel Corp., vice-president of the Seaboard Airline Railroad, and the Atlanta, Birmingham & Coast Line Railway.

Robert C. Stanley (Member 1902), chairman of International Nickel Co., died on Feb. 12 of a heart attack. Mr. Stanley was born in Little Falls, N. J. on Aug. 1, 1876. He attended Stevens Institute of Technology where he received a mechanical engineering degree in 1899. He was granted a degree of mining engineer at Columbia School of Mines in New York in 1901. Following his graduation from Columbia he was employed by the S. S. White Dental Co., Philadelphia, to investigate platinum



ROBERT C. STANLEY

placer sands in British Columbia. When he returned he assayed the samples at the precious metals refinery maintained by Orford Copper Co., Bayonne, N. J. Early in 1902 the International Nickel Co. was formed with the Orford Copper Co. and the American Nickel Co. Mr. Stanley was made assistant superintendent of the Camden, N. J. plant of the American Nickel Co. and subsequently became superintendent. In 1904 he was transferred to Bayonne as assistant general superintendent of the Orford Copper Co. and in 1912 he was general superintendent. Under his direction during World War I this plant was successful in substantially stepping up its production to meet wartime demands. In 1917 he was elected a director, and in 1918, vice-president in charge of all operations of International Nickel and moved to the executive offices in New York. Mr. Stanley became president in 1922 and one of his initial efforts at that time was the formation of a development and research div. He assumed the chairmanship of the company's board of directors in 1937. On Feb. 7, 1949 he relinquished the presidency, remaining chairman of the board. Mr. Stanley effected numerous advances in nickel metallurgy, such as the substitution of a modified Edwards mechanical roasting furnace for the hand-rabbled furnaces previously considered standard in roasting matte. In 1905 he discovered monel and in 1906 was in charge of the first production of this metal by direct roasting and reduction of selected ores to make this nickel-copper alloy in a continuous process. He later patented an improved process for monel refining. He was also the recipient of numerous honors and also held directorships for various concerns both here and abroad.

NECROLOGY

Date Elected	Name	Date of Death
1902	L. R. Budrow	Jan. 6, 1951
1915	Luis F. Diaz	Unknown
1929	August Grunert	Feb. 18, 1951
1930	Alexander Flyter Ross	October 1950
1902	Robert C. Stanley	Feb. 12, 1951

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Jan. 31, 1951, was 17,228; in addition 4613 Student Associates were enrolled.

ADMISSIONS COMMITTEE

Albert J. Phillips, Chairman; George B. Corless, Lloyd C. Gibson, Ivan Given, Plato Malozemoff, R. D. Mollison, John T. Sherman, Harold K. Work. Alternates: Harry P. Croft, Fred W. Hanson, T. D. Jones, Frank A. Auer, H. W. Hitzrot, and H. K. Masters.

Institute members are urged to review this list as soon as the issue is received and immediately write the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate.

Alabama
McMalla—Serugham, Hal M. (M) (C/S—J-M)

Arizona
Clifton—Gomez, Rodrigo J. (J)
Phoenix—Douglas, John E. (M)
Ray—Robb, Andrew B. (M) (R. C/S—J-M)
Tucson—Griswold, William T. (J)
Tucson—Stewart, Lincoln A. (M) (R.)

California
Concord—Bowman, Robert B. (M)
Huntington Park—Didier, Frank D., Jr. (J) (C/S—S-J)
Oakland—McGuire, Philip J. (M)
Whittier—Brooks, Richard F. (M)

Colorado
Climax—Bienemann, William J., Jr. (J) (C-S—S-J)
Uravan—Finch, Frank (J) (C/S—S-J)

Delaware
Wilmington—Evans, Clarence H. (M)

Florida
Pierce—Faulds, Norval M. (M) (C/S—A-M)

Idaho
Wallace—Cox, Manning W. (M) (C/S—J-M)
Wallace—Jessup, Paul B. (A)
Wallace—Vaughan, Everett E. (A)

Indiana
Evansville—Hennessey, William R. (M)

Iowa
Iowa City—Davis, Stanton H., Jr. (J) (C/S—S-J)

Louisiana
Shreveport—Forgotson, James M. (M)
Shreveport—Saunders, Donald J. (J) (C/S—S-J)

Maryland
Garrett Park—Quigley, W. Donald (M) (R. C/S—S-M)

Michigan
Grosse Pointe Woods—Stricker, Adam K. (M)

Missouri
Rolla—Burke, Robert F. (J)
Webb City—Reynolds, James V. (M)

Nebraska
Leigh—Motycka, Delmar A. (J) (C/S—S-J)

Nevada
McGill—Immonen, L. G. (M) (C/S—A-M)
Reno—Reeves, Robert G. (M) (C/S—S-M)
Ruth—Smith, Simeon W. (M)

New Mexico
Carlsbad—Bishop, Kenneth G. (A)
Carlsbad—Edmonds, Byron P. (M) (R. C/S—J-M)
Hanover—Barnes, Hubert L. (J)

New York
New York—Beall, John V. (M) (C/S—J-M)
Schenectady—Moore, Robert B. (A)

Ohio
Columbus—Bailey, Leo C. (J)
Columbus—Rhodes, Leslie A. (M)
Youngstown—Siegrist, Ralph S. (M)

Oregon
Albany—Toepfer, Peter H. (M)
Portland—McGuinness, Albert L. (J) (R. C/S—S-J)

Pennsylvania
Camp Hill—Weigle, David J. (M)
Easton—Beynon, Arthur F. (M) (C/S—J-M)
Kingston—Smith, Ralph W. (M)
Pittsburgh—Gilbert, Alfred G. (M)

Utah
Bingham Canyon—Matheson, Kenneth H., Jr. (J) (R. C/S—S-J)
Park City—Kuhlman, Fredrick A. (M) (R. C/S—J-M)
Salt Lake City—Gibbons, John P. (A)
Salt Lake City—Gundersen, Howard B. (A)
Salt Lake City—Lacy, Robert J. (M) (R. C/S—J-M)
Salt Lake City—Oliver, Clinton R. (M)
Salt Lake City—Young, Wallace (M)
Sandy—Fullmer, H. Smith (M)

Washington
Vancouver—Kirchner, Henry P. (J)

West Virginia
Wharton—Steingasser, Joseph N. (J) (C/S—S-J)

Wisconsin
West Allis—Ramstack, Rudolph J., Jr. (J)

Africa
French Morocco—Spada, Mario

Alaska
College—Lean, Clements N. (J) (R. C/S—S-J)

Australia
Queensland—Howe, Alwyn W. (J)

Brazil
Rua Bom Pastor—Jafet, Roberto N. (M)

Canada
British Columbia, Brittannia Beach — Smith, Archibald T. (M)
Ontario—Little, William M. (J)
Ontario—Mutch, Alexander D. (J)

Central America
Nicaragua—Webber, Joseph G. (J)

East Africa
Tanganyika—Ewins, Russell H. (M)

England
London—Tokarski, Stanislaw (J) (C/S—S-J)

Japan
Tokyo—Kuroda, Hajime (M)

— Coming Events —

Apr. 9-11, Canadian Institute of Mining & Metallurgy, Chateau Frontenac, Quebec City.

Apr. 10, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

Apr. 11, AIME, Chicago Section, Chicago Bar Assn., 29 S. LaSalle St., Chicago.

Apr. 15-18, Scientific Apparatus Makers Assn., annual meeting, Greenbrier, White Sulphur Springs, W. Va.

Apr. 16-18, American Society of Lubrication Engineers, national convention, Bellevue-Stratford Hotel, Philadelphia.

Apr. 17-20, American Management Assn., National Packaging Exposition, Auditorium, Atlantic City, N. J.

Apr. 20-21, Engineers' Day, Colorado School of Mines, Golden.

Apr. 23-26, American Foundrymen's Society, annual convention, Buffalo, N. Y.

Apr. 25-26, Metal Powder Assn., annual meeting, Hotel Cleveland, Cleveland.

Apr. 30-May 1, Assn. of Iron and Steel Engineers, spring conference, Hotel Statler, Detroit.

Apr. 30-May 4, Materials Handling Exposition, International Amphitheatre, Chicago.

Apr. 30-May 11, British Industries Fair, annual industrial show, Olympia and Earls Court, London; Castle Bromwich, Birmingham.

May 4, Anthracite Conference, ninth annual meeting, Lehigh University, Bethlehem, Pa.

May 7, AIME, Mexico Section, American Club, Mexico City.

May 7, AIME, Florida Section, Lakeland, Fla.

May 7-11, Greater New York Industrial Show, 71st Regiment Armory, New York.

May 9-11, Engineering Institute of Canada, annual meeting, Mount Royal Hotel, Montreal.

May 13-16, American Institute of Chemical Engineers, regional meeting, Hotel Muehlebach, Kansas City, Mo.

May 14-17, American Mining Congress Coal Mining Convention & Exposition, Auditorium, Cleveland.

May 21-22, American Zinc Institute, annual meeting, Hotel Statler, St. Louis.

May 22, AIME, Morenci Sub-section, Longfellow Inn, Morenci, Ariz.

May 23-24, American Society for Quality Control, annual convention, Hotel Cleveland, Cleveland.

June 11-14, Armour Research Foundation of Illinois Institute of Technology, Sheraton Hotel, Chicago.

June 11-15, Conference on Industrial Research, Columbia University, New York.

June 11-15, ASME, semi-annual meeting, Royal York, Toronto, Canada.

June 18-22, ASTM, annual meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

Sept. 16-19, American Institute of Chemical Engineers, regional meeting, Sheraton Hotel, Rochester, N. Y.

Sept. 25-28, ASME, fall meeting, Radisson Hotel, Minneapolis.

Oct. 1-4, Assn. of Iron and Steel Engineers, annual convention, Hotel Sherman, Chicago.

Oct. 3-5, AIME, Petroleum Branch, fall meeting, Oklahoma City.

Oct. 11-12, AIME, fuels conference, Roanoke Hotel, Roanoke, Va.

Oct. 15-17, AIME, Institute of Metals Div., fall meeting, Detroit-Leland Hotel, Detroit.

Oct. 15-19, National Metal Congress & Exposition, Detroit.

Oct. 22-24, American Mining Congress, Metal and Nonmetallic Mining Convention, Biltmore Hotel, Los Angeles.

Oct. 29-Nov. 3, AIME, fall meeting, Mexico City.

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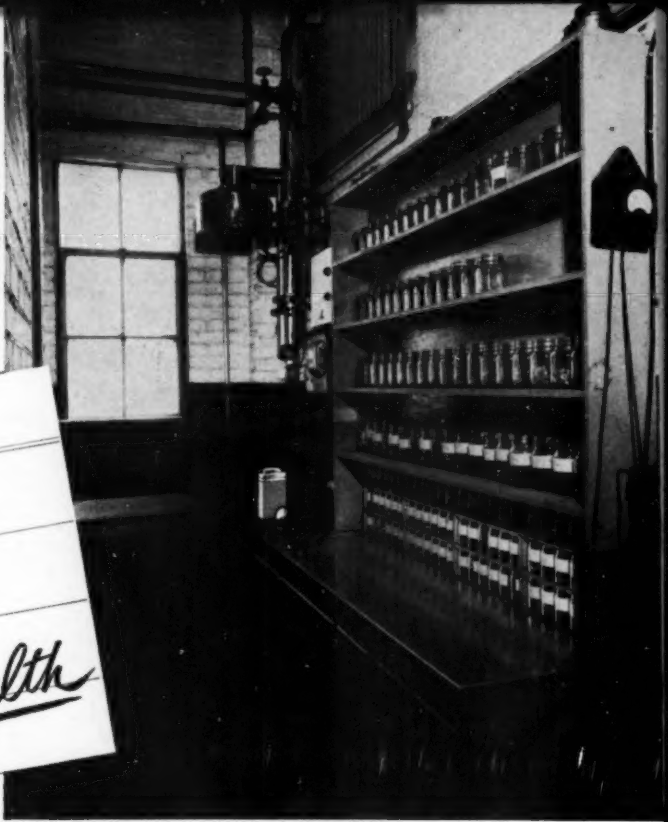

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